The Welding Engineer

PIONEER BUSINESS AND TECHNICAL JOURNAL OF THE WELDING INDUSTRY

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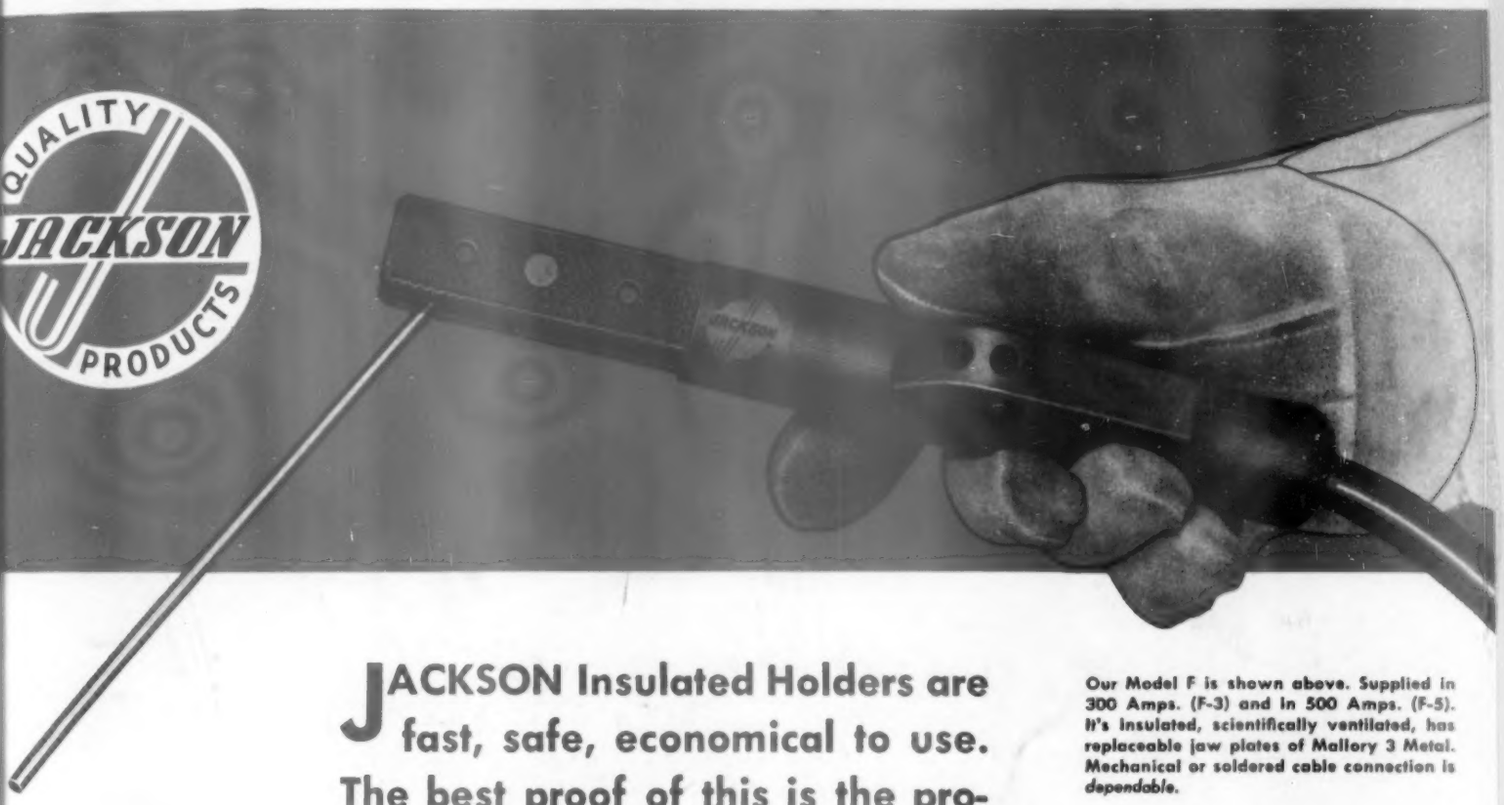

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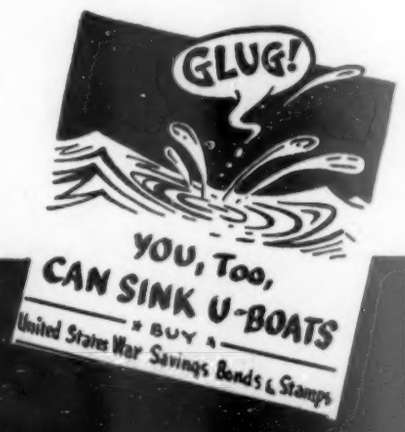

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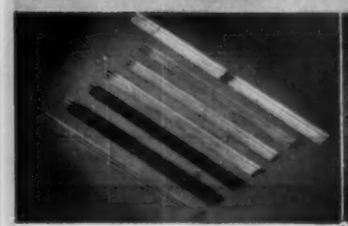

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The Welding Engineer

AMERICA'S PIONEER WELDING JOURNAL

SEPTEMBER 1942

Established 1916

Patent Problems

"After the war, will this country return to a system of free enterprise and competition, or will it continue on an allocations plan?"

This question was asked me a few days ago. It is a question of grave importance, yet it is a most difficult question to answer. Free enterprise is constantly being harassed, the latest attack being made upon our patent system.

The patent system is said to be "monopolistic." If this is true, it would appear that the proper remedy would be an adequate enforcement of the Anti-Trust laws rather than an attempt to destroy our historic system of patent laws. Such an attempt seems rather like pulling down the house to fix the chimney, yet the Senate Patent Committee is now considering two bills (S. 2303 and S. 2491) designed to revise radically our country's patent system.

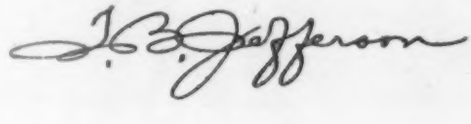
The thoughts in these bills were suggested by Thurman Arnold, Assistant Attorney General in charge of the Anti-Trust Division of the Department of Justice. If they become laws, they will strike a serious blow at our present system of free enterprise. Under existing patent laws, inventors who obtain patents on their inventions are protected and afforded an opportunity to seek rewards for their years of labor in perfecting an invention. The proposed laws will do away with this protective feature and eliminate the incentive for inventors to invent or for industrial research expenditures by industry.

Industrial progress is based upon the inventive genius of the workers in industry. To take away the patent system and its opportunity for reward will mean a decline in inventions and consequently a decline in industrial progress as we now know it.

To continue as a nation with free enterprise we must have inventions. Every war is followed with a period of reconstruction which has been accelerated by inventive genius. After the Civil War came the telegraph and railroads, World War I was followed by radio and motion pictures . . . to cite only a few inventions which helped the country's return to normal times.

Inventions will be needed more than ever to attain normalcy after World War II!

Will future free enterprise depend on the whims of Mr. Arnold who would change patent laws which have served so well even while he makes the significant admission: "I do not feel myself competent to testify as to the purely patent aspect of the patent law."



It's healthier on the Attacking Side

Whether you're fighting a Jap 5 miles up or tackling a problem in the shop . . . it helps a lot to have the jump on your competitor.

ALTER EGO: True as gospel. Competition forces progress. We've changed over to welding of ships, planes, tanks and guns. Why? Because the Axis had a head start in designs and output. They *forced* us to make 'em better and build 'em faster.

Imagine that! It took a threat to our very lives to drive home the necessity of converting old methods to new!

ALTER EGO: But have we learned our lesson? Will we be content to plod along after this scrap is over? As for me, I'm going to convert now to the offensive for tomorrow's Battle for Business.

That's the spirit! Let's take off our rose-colored glasses and put on our reading glasses. Let's learn all about welding so we can get the jump on competition.

THE LINCOLN ELECTRIC COMPANY
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ALTER EGO: Literally, "one's other self"— the still, small voice that questions, inspires and corrects our conscious action.

Photo Courtesy: Lockheed Aircraft Corp.

★ RESEARCH

Heliarc Welding

Recent developments in the arc welding of magnesium alloys may revolutionize the production of aircraft.

By **THOMAS E. PIPER**
Process Engineer,
Northrop Aircraft, Inc.

Arc welding magnesium in an atmosphere of gaseous helium. This new process will make possible the use of a virtually inexhaustible metal for the construction of fighter and bomber planes.

The Heliarc method of welding magnesium is the result of collaborative research by Northrop Aircraft, Inc., and the Dow Chemical Co. In a subsequent issue of THE WELDING ENGINEER *there will be published an article relating to the metallurgical aspects of this welding process.*

CULMINATING RESEARCH over a two year period, Northrop Aircraft, Inc., is introducing and giving to the war industries "Heliarc" welding. This new method of arc welding, it is expected, will prove a tangible weapon to promote the defeat of our enemies. The new method has made possible the use of a new material for aircraft construction—a material which lies in virtually inexhaustible quantities off our own shores—and it has simplified methods of construction that will speed plane output.

The innovation has been made possible by the courage and perseverance of two men, V. H. Pavlecka, chief of research, and Russ Meredith, welding engineer, together with other men of the Northrop organization. This new development permits the arc welding[1] of magnesium sheets, extrusions and tubing into structures simpler, lighter and stiffer than is possible in conventional duralumin construction.

No More Rivets

The use of magnesium welded structures will eliminate the hundreds of thousands of rivets that go into the conventional plane. Rivet heads on the fuselage and wings, even though countersunk, produce resistance to passage through the air, or "parasite drag." At high speeds, a substantial portion of the engine power is used to overcome this parasite resistance. In the future, welded magnesium aircraft can be finished just as smoothly as a fine automobile, presenting to the airflow a perfectly uniform and rigid surface.

While magnesium has been used for some time in the aircraft industry for engine parts, wheels and accessories, it has not been used extensively as a primary construction material because of the difficulties in fabricating. The Heliarc welding process now makes possible the all-magnesium plane with its many advantages.

Magnesium Plentiful

Magnesium is the most abundant metal on the earth and in the ocean. Indeed about 15% of all the dissolved solid matter in the sea consists of magnesium chloride and magnesium sulphate — enough to cover all the land areas of the earth to a depth of 60 or 70 ft or 9,000,000,000 lb per cubic mile. The mother liquors from the brine of salt wells are always rich in both magnesium salts and bromides. Nearly all the silicate rocks of the earth's crust contain notable quantities of magnesium. Some of these are of commercial importance; examples are talc, soapstone, asbestos, cement and marble.

Cost to Come Down

The cost of magnesium alloys at the present time is somewhat greater than that of aluminum alloys. However, because of new magnesium plants under construction and increased production in the plants now in operation, magnesium alloys will be less expensive than aluminum alloys in a very short time. In present production methods, 24,000 kwh of electricity are required to produce a ton of aluminum from bauxite while only 18,300 kwh are required to produce a ton of magnesium, which has 54% more volume. Magnesium alloy will shortly be the most plentiful alloy on our own continent. The world's largest deposits of brusite, a magnesium bearing ore, are in Montana, Washington and British Columbia.

Contrary to popular belief, magnesium alloys are not inflammable when properly processed; they are, in fact, more resistant to direct flames than aluminum alloys. Although magnesium alloys are 35% lighter than aluminum alloys (and 21% of the weight of steel per unit volume), their weight strength ratio is com-

[1] For gas welding of magnesium see: "Gas Welding of Magnesium Alloys," page 22, March, 1941, issue of THE WELDING ENGINEER.

parable to aluminum alloys, and they possess the design properties of stiffness and rigidity that cannot be obtained in other alloys.

Welding Magnesium

In the Heliarc welding process, a tungsten electrode provides a heat source to melt a filler rod. The filler metal and the arc flame are shielded by a helium envelope. Because helium is an inert gas, it prevents oxidation. The use of a flux and the danger of entrapped flux in the weld deposit are also eliminated.

Heliarc welding torch. This torch is equipped with a valve that opens for the emission of helium just prior to the striking of the arc between the tungsten electrode and the parent metal. Torches are of two sizes and may be obtained with tips of three different angles. Electrodes range in size from 1/16 to 1/4 in.

Heliarc welding has proved to be a successful medium of attachment for magnesium, stainless steel, brass, Inconel, Monel and some of the carbon steel alloys. Research work is now in progress to extend its use to aluminum and to the carbon steel alloys not heretofore Heliarc welded. With this new welding process, the future use of magnesium alloys for the fabrication of structures (especially aircraft) should be greatly enhanced.

Dense, Strong Welds

Magnesium castings containing foundry defects have been repaired by this arc welding process, and welds equal to or stronger than the surrounding metal have been obtained. The weld metal is much more dense than that of the surrounding cast metal and far less susceptible to corrosion. Almost any thickness of cast metal that can be poured may be readily welded with this process.

Welding rod of the same alloy as the parent metal is usually used for castings and wrought alloys. The weld deposit appears to have better corrosion-resistant properties than the parent metal in salt spray tests. The weld bead is believed to be cathodic to the adjoining metal, which causes minor pitting of the original metal adjacent to the weld under severely corrosive conditions.

Torches and Electrodes

Heliarc torches are of two sizes, suitable to handle electrodes of $\frac{1}{16}$ to $\frac{1}{8}$ in. and $\frac{3}{16}$ to $\frac{1}{4}$ in., respectively. They may be obtained with tips of different angles—40 deg, 60 deg and 90 deg. The tungsten electrode varies in size from $\frac{1}{16}$ to $\frac{1}{4}$ in., depending upon the thickness of metal welded and the heat required.

The torch may be used for pencil welding or, by extending the handle, a handle bar grip is obtained for heavier welding. Best results are obtained by feeding the filler rod into the tungsten electrode, which melts off portions of the rod thereby forming a uniform weld deposit. This procedure has been found to be superior to the practice of feeding the filler rod into the molten pool under the arc because, in the latter case, the molten pool is not sufficiently agitated to break the crust which gathers on the surface of the pool. Since the reflected heat from the tungsten overheats the filler rod, an angle of 60 to 90 deg must be maintained between the filler rod and the electrode. The torch must be held as near the weld as possible in order to obtain maximum benefit from the helium for the prevention of oxidation. Also an arc length of 0.060 in. maximum should be maintained. Poor penetration or gas holes may result by using too long an arc.

Shield of Inert Gas

The torch is equipped with a helium valve that is opened just prior to the striking of the arc; this valve feeds helium through the torch to the point of welding. Helium has over five times the specific heat of air. When in motion, it prevents heat accumulation around the weld, keeping it cooler and giving a better fusion and penetration, with less distortion than in other welding processes.

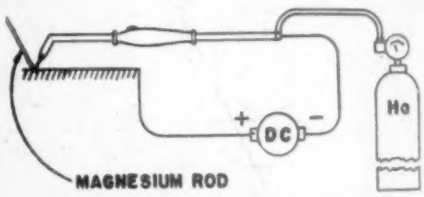
The arc is struck by a light brushing action and quickly drawn back from the metal. The arc in this process is produced directly between a tungsten electrode and the base metal rather than between two tungsten electrodes as is the case in atomic hydrogen welding. The tungsten electrode is very slowly alloyed with the weld metal and must, naturally, be replaced in a period of time. No noticeable increase in the corrosion rate of Heliarc welds in magnesium alloys because of the presence of tungsten has been detected. On those alloys that have a tendency to be hot short, a rapid welding speed—approximately 3 ft per min—is recommended to eliminate the danger of cracking.

Fine-Grained Deposits

Heliarc weld deposits have in general an extremely fine grain with practically no grain enlargement adjacent to the bead, indicating that there is a minimum of heating effects on the adjacent metal. This accounts for the very good weld efficiencies obtained on Heliarc welded alloys.

Dowmetal J-1H magnesium alloy, Heliarc welded, has approximately 95% of the parent metal strength in the weld area. However, at present, the design safety factor for welded Dowmetal J-1H assemblies is 75% of the strength of the parent metal. These strength values are based on butt welded joints. Fillet, lap, edge or corner welds are weaker than the butt welded joint and must be stressed accordingly.

A conventional arc welding machine with a D-C generator having a 150 amp output is desirable. However, higher output machines which operate at less than 300 amp may be used, providing lower amperage may be obtained. Separate amperage and voltage regulators must be provided, and the machines should have a continuous sequence of five increments of current control.



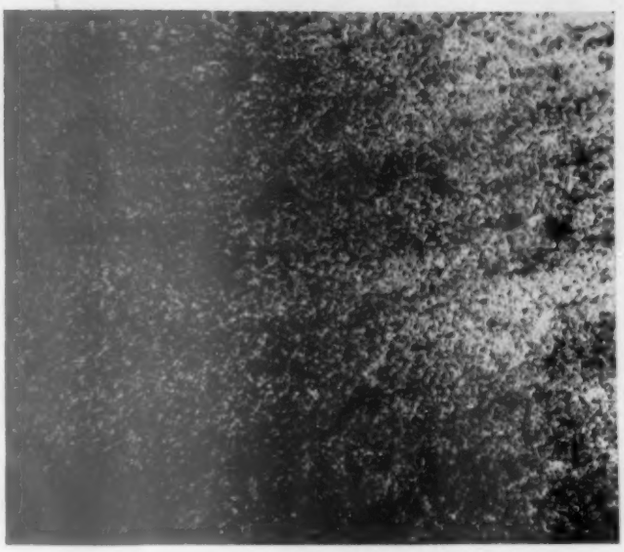
Heliarc welding circuit diagram. The tungsten electrode is used with straight polarity, making the magnesium work the anode. Reversed polarity and a carbon electrode are used for the welding of ferrous and copper alloys by this process.

In the Heliarc welding of magnesium structures, the tungsten electrode is used with straight polarity (making the magnesium work the anode). For ferrous and copper alloys, a carbon electrode is used, and the welded structure is the cathode. Craters are eliminated in reverse polarity welding.

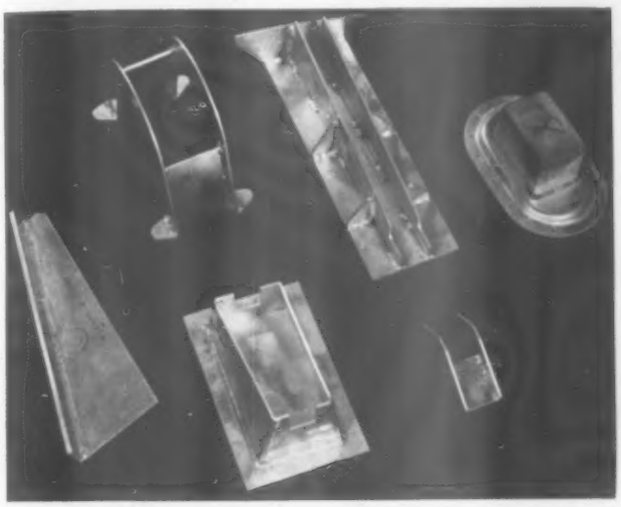
Pure Helium Needed

Normally helium as purchased from the Government plant is sufficiently pure to cause no difficulty. Fairly pure helium gas is required. Additional gases in helium, such as carbon dioxide, hydrogen, nitrogen and the hydrocarbons, may cause pronounced defects. Hydrogen produces bad porosity. Oxygen films the metal, causing poor coalescence and inclusions. The presence of 7% nitrogen reduces the welding speed to about two-thirds that obtained when only 2% nitrogen is present. Gas impurities may be removed, fortunately, by passing the helium through filtering mediums.

The average life of a 200 cu ft cylinder of helium is about 35 hrs of continuous welding with a medium-sized torch.



Photomicrograph of grain structure of weld, magnification 500 diam. Weld (darker half of print) is made of Dowmetal "J" alloy rod which is blended with Dowmetal "J" parent metal (lighter half).



Heliarc welded magnesium production specimens made by Northrop Aircraft, Inc.

New Tool for Welding

This method of arc welding has provided an important new tool for the fabrication of structures from alloys such as magnesium and stainless steel. Any type of joint which has been commonly used for welding ferrous metals may be employed on magnesium and stainless steel.

For the high temperature melting and heat resisting alloys, Heliarc welding has proved successful where former welding methods failed.

★ ★ ★

M-4 Tanks in Action

THOUGH the M-4 type military tank was on the drafting table at the time of the attack on Pearl Harbor, these tanks have already proved themselves on the field of battle.

The newest weapon of our armored force is now being turned out by the hundred from the assembly lines of tank arsenals. Depending upon where they are assembled, the tough armor covering of these highly maneuverable land cruisers may be either all-weld, cast or a combination. Regardless of the method of hull construction, however, the M-4 lacks the death-dealing rivets of its predecessor—the M-3.

The M-4 is also superior to the M-3 because of its increased fire power and the improved location of its 75 mm cannon, which is now in the turret. This turret, of cast and welded construction, is full-revolving.

Official OWI Photo by Palmer

Welding is important to the construction of this new weapon.

Saving Scrap Losses Through Material Control

★Part I—All too often, the best functional design will prove to be the most wasteful for cutting. Mr. Brooking offers here a thorough study of ways and means to offset that tendency and to improve the efficiency of flame-cutting.

By WALTER J. BROOKING
Director of Testing and Research,
R. G. LeTourneau, Inc., Peoria

Fig. 1—The curved, stress distributing lines of this scraper yoke develop maximum functional strength with the least material but render more difficult the problem of how to cut the plates without excessive scrap loss.

ONE OF THE MOST important sources of economy in fabricating manufactured articles by welding methods is that steel can be purchased from the mills in the "as rolled" condition in the form of plates, bars, strips, sheets, angles, channels, special shapes, etc. Welding permits the fabrication of such rolled steel into finished products at prices substantially cheaper than that of special castings. The margin of economical operation, however, depends directly upon the efficiency with which the raw materials are used.

Finding the True Cost

The actual cost of the material used in a finished part cannot be found by multiplying the number of pounds in the part by the cost per pound at which the material was purchased. It must be obtained by taking the total cost of the material purchased to produce a given number of parts, subtracting from this the scrap value of the portions sold as scrap and dividing the remainder by the total number of parts produced. Thus scrap losses loom large in the final cost picture.

In some types of welded constructions, a high percentage of the total raw material may be used in the finished parts. Then only a small percentage of the material becomes scrap, and the cost per pound of the material in the finished part is very little above the purchased price per pound of the total amount of material.

In other cases, however, large scrap losses may seem almost unavoidable. As a simple example, let us consider the scrap loss involved in flame-cutting a circular part from a square or rectangular plate. The area of a circle is 78.5% of the area of a square with sides equal to the circle's diameter. The theoretical loss is, therefore, 21.5%. The actual loss, however, may be closer to 30%—about 600 lb of steel out of every ton purchased.

Irregular Shapes Common

In many types of machinery, the best functional design — the design which uses the least weight of material to obtain the maximum strength where needed—makes considerable use of irregularly shaped parts. An example is shown in Fig. 1, a scraper yoke for a large earth-moving machine. The structure is about 10 ft high by 8 ft wide by 8 ft long and is made entirely from steel plates and shapes, many of which are subsequently processed by bending or rolling. The irregular shapes to be flame-cut make the problem of full utilization of plate stock vastly more difficult than it would be if a squarer (but less efficient) functional design had been selected.

Since there is a tendency for the best functional designs to be also the most wasteful in the cutting shop, it becomes vitally important to find all the ways and means possible for offsetting the resultant scrap losses.

Cost and Scrap Value

Whatever the manufacturer pays for his original stock of steel (and

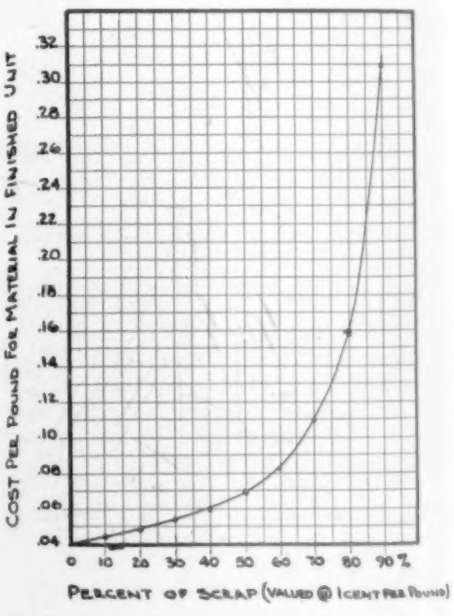


Fig. 2—How rapidly the cost of material in the finished unit increases with the percentage of scrap is shown by this graph. Three quarters of the original value of a pound of metal is lost when it becomes scrap.

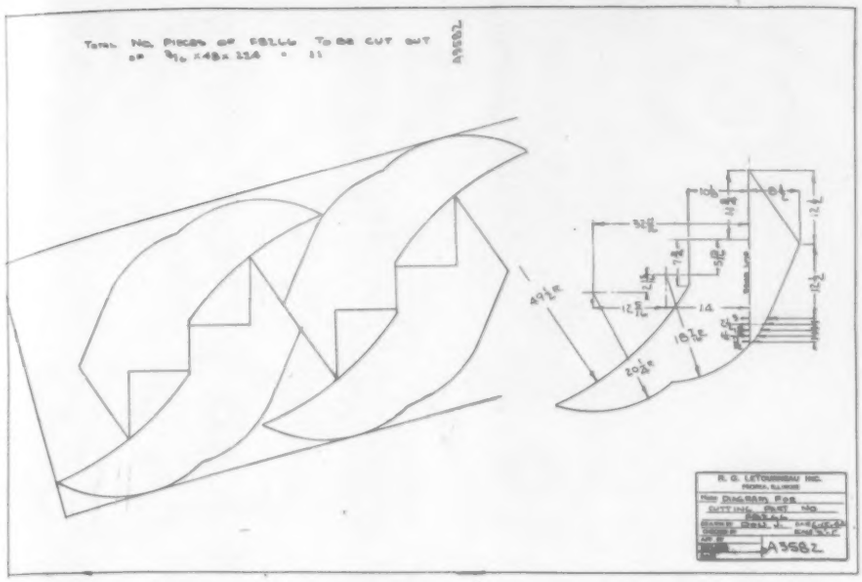


Fig. 3—This working drawing shows careful planning by the engineering department. It tells the shop how many parts to cut from a given plate and how to plan the cutting for least scrap.

that depends mainly upon whether it is alloy or plain carbon and somewhat upon the amounts used), the fundamental relationship between original cost of the material and the material cost in the finished structure is about the same.

Suppose that the original cost of the steel purchased for the production of a particular machine is 4c per lb. Even at the present high value of scrap, and even with the best sorting and marketing conditions, the manufacturer is not likely to get more than 1c per lb for his scrap. All scrap, therefore, represents a 75% loss on the value of the original material. Actually, it represents more than 75% loss because the cost of handling the scrap from the time it is cut from the original plate until it is delivered to the dealer must be deducted from the scrap value of 1c per lb. For this study, however, the scrap value will be considered as 1c per lb.

The 75% reduction in original value of all scrap material has to be charged to the cost of the material in the finished product. Therefore the percentage of scrap produced has a very significant bearing upon the actual cost of the material which makes up the finished unit.

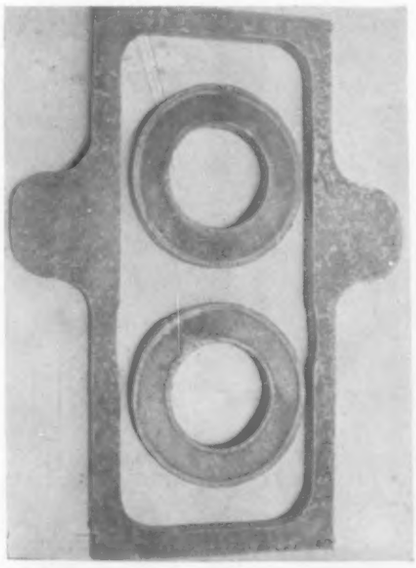


Fig. 4—The two rings and the framelike part above require the same thickness and hence may be cut from the same plate. If the "doughnuts" are nested close together, a sizable piece of scrap will be left for the cutting of other parts.

Fig. 5 (right)—Flame-cutting a 96 in. by 240 in. plate, 2 in. thick, for two different orders at the same time. Note plan of nesting large and small circle. The cutting sequence is explained in detail in the text.

Fig. 2 shows graphically how the cost per lb of the material in the finished unit increases as the percentage of scrap produced becomes larger. The curve soars upward at an angle ever increasing toward the vertical. The amount of scrap left after the parts have been cut from the original material provides, therefore, a very effective index as to the actual cost of the material in the design. Furthermore, the utilization of the material remaining after the cutting represents a very important margin of economy.

Low Scrap Factors

Several factors are involved in the maintaining of a low percentage of scrap from the original plate stock. Some of the most important are:

(1) An original design involving the least scrap.

(2) Careful planning in the shop to coördinate the cutting of different orders. Parts which produce considerable scrap should be cut with other parts if possible.

(3) The machinery used for cutting. Sometimes the amount of material which can be rescued from scrap by a certain type of cutting machine will go a long way toward paying for that machine.

(4) Balancing the cost of processing against the value of the material. When is it more economical to cut parts from scrap and when to use a new piece of material? The answers to these questions should be known.

In general, a manufacturing organization has four sections which can help to maintain the use of material on a high level of efficiency. They are:

(a) Engineering department.

Fig. 6—Scrap piles should be orderly, separating sizes and shapes into like kinds so far as is practicable. For most efficient operation, piles should be close to the flame-cutting machine.

(b) Production department (or shop steel clerk).

(c) Shop processing equipment division.

(d) Tool and die department and experimental departments.

Engineering Department

Being responsible for the original design of a unit, the engineering department is in a position to exert considerable influence in maintaining a high efficiency in the use of material. This department should make careful study of the steel stock commonly used in the shop and should select materials from which the particular part being drawn can be cut most efficiently.

By making a very slight change in the shape of a part in the original design, it is sometimes possible to obtain the same strength and approximately the same weight while simplifying the necessary cutting and reducing the amount of scrap.

The engineering department may also plan the cutting of irregularly shaped parts. The nesting of these parts so as to cause the least amount of cutting and produce the smallest amount of scrap may be worked out scientifically and then indicated on the shop working drawing of the part as in Fig. 3. The inset on this drawing gives the proper method of laying out an irregularly shaped part on a strip of plate stock 48 by 224 in. so that a total of 11 pieces may be cut with the smallest possible space between them.

It does not usually take a detail draftsman very long to make such a layout as shown in Fig. 3. Not only is the time and effort of the shop organization in planning this phase of the work saved, but also the cost of the additional scrap which might result from poor shop planning.

The designing department should also be alert to any possible cuttings of different parts from the same material. An example of this type of planning appears in Fig. 4. The two doughnut-shaped parts and the one framelike part are cut from the same 1 in. steel plate. Two of the doughnuts are used for every one of the frames and can be cut from the section removed from the inside of the frame. By nesting the two rings close together, a piece ⅔ as large as one ring is left from which other parts may be cut later. Both rings are cut from the plate at the same time as the frames, thus saving the handling of the center pieces for a separate cutting.

Through careful planning, a large number of gussets, caps, lugs, supporting members, even bars and strips may be cut from scrap. Much can be done by an alert engineering department to maintain the initial advantage in economy provided by the welding process through the use of inexpensive raw material.

Shop Steel Clerk

Another source of real economy is attained by having an alert steel clerk whose duties are the planning of cutting operations to make the best use of the material on hand. Such a clerk should:

(1) Be familiar with all of the current orders for parts in the cutting department. This involves a knowledge of the orders on hand, the orders that are to come in the near future and the cutting schedules.

(2) Know in detail, from studying the prints, the material from which parts are to be cut and bear in mind that one order of parts might possibly be cut from the scrap of another order instead of from new material.

(3) Have thorough knowledge of the shop's production methods.

(4) Have thorough knowledge of the scrap (quantities, dimensions, types of materials on hand) left over from previous jobs.

(5) Have thorough knowledge of the types, shapes and general sizes of most of the parts produced in the shop, together with the relative quantities used, so that he can determine

Fig. 7—Note the small size and irregular shape of the parts being cut from these pieces of 1 in. plate scrap. Thorough utilization such as this reduces scrap losses toward the vanishing point.

whether or not parts may be cut from scraps left over from another order.

(6) Have authority to decide whether scraps from the cutting of a certain order shall be placed in storage for future use or disposed of immediately.

(7) Have a general knowledge of the cost of processing by different methods and the original cost of the material.

In Fig. 5 we see an example of how a good steel clerk should function. Two separate parts for two separate orders are being taken from a 3 in. plate, 96 in. wide by 240 in. long, at the same cutting. Not only does this make good use of the material, but it also reduces handling costs to the barest minimum.

Savings in Circles

The large circles are being cut for one order and the smaller circles for another order. The planning of the cutting sequence in this particular operation is no mean accomplishment. First step in the sequence is to cut a small circle from the part which will be left between the large circular parts. The second step is the cutting of another small circular part from the scrap portion to be cut out to make the inside diameter of the large circle. The spacing of the centers of the small circles is very important because an error might ruin the cutting of the larger circle.

The third step is to cut the ID of the larger part. The last cuts, the OD of the large circles, are made so that they intersect and cause the separation of the scrap into small parts. This cutting plan produces two of the smaller parts to each one of the large parts. The remaining scrap is disposed of in a portable scrap bin which can be dumped into a car at the time this scrap is sold. This efficient method of disposition reduces the handling of scrap to the minimum.

Using a flame-cutting machine fitted with three torches, as shown in the picture, two complete plates can be cut in 18 hr.

Though it is not always possible to cut a plate as efficiently as shown in Fig. 5, there are often parts remaining after an order has been cut which may profitably be stored, in anticipation of possible later needs, in the form of a plate stock scrap pile. When an order which can be cut from the left-overs comes to the shop, the steel clerk will then have the most suitable pieces brought in and will cut the order from the scrap on hand.

An Orderly Scrap Pile

A good plate stock scrap pile is shown in Fig. 6. The pieces are piled according to size (and, in general, according to shape) as near to the flame-cutting machine as is convenient. Note the large strip in the foreground which has been trimmed slightly before placing in the scrap pile. The trimming and conditioning of scrap parts is a safety practice as well as a convenience in piling, and it is seldom that pieces which are cut off in this fashion will cause loss in the final cutting up of the scrap.

It is not uncommon, with careful planning, to take numerous orders of small parts such as those shown in Fig. 7 from the plate scrap pile in almost the same time that it would take to cut the order from new plate stock. Remember that until scrap stock has actually been sold to the dealer, it is worth as much as it cost originally if it can be utilized for manufacturing.

Three Piece Economy

Frequently, a little study of the sizes and shapes of the scrap parts left after cutting major parts from stock will show that a slight redesign or change of practice may result in considerable savings in material. An economy of this nature is shown in Fig. 8. The double-ended wrench was at one time cut from plate stock as a single part, which nested only moderately well in the original plate material. It was decided to flame-cut the two heads as separate parts from scrap plate stock and then weld them to a piece of bar stock previously sheared to length. Much better use of material was accomplished, and a large portion of the cost of welding was defrayed by the saving effected through shearing the handle part of the wrench.

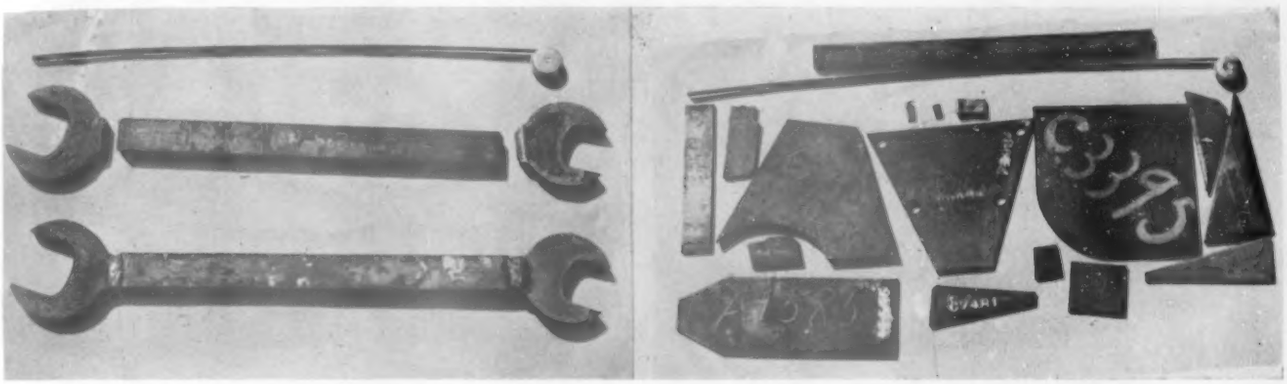


Fig. 8 (left)—The double-ended wrench was originally flame-cut in one piece from plate stock. It proved cheaper, however, to flame-cut the heads from plate scrap and shear the handle from bar stock, welding the three pieces together as shown here.

Fig. 9 (right)—A large variety of parts like these can be obtained from scrap sections with considerable economy.

What has been said in the last few paragraphs concerning the planning and use of heavy plates is generally true of most other raw material as well. The same careful planning applies to thin plates as to thick ones and applies to angles, bar stock, channels and any of the other standard shapes purchased. Thin plates which have been routed to the scrap pile may often be cut by plate shear into a large variety of plates, lugs, gussets, caps and other small parts like those shown in Fig. 9.

Handling Scrap Storage

If possible, the scrap sections should be piled close to the machine which will cut parts from them and should be segregated according to size and types. Sometimes it is advisable to build inexpensive racks for the storage of standard types of scrap which can be utilized regularly but which may have to be accumulated for a while before an order can be cut. However, a careful study should be made prior to the building of storage racks because the investment in time and labor may exceed the value of the parts which will be taken out of the scrap.

Part 2 will appear in October.

550 Miles of Pipe Welding

The welding of the world's largest oil-carrying pipe line was too big for any one contractor, so the Government divided it among seven builders.

Fig. 1 (left)—Tack welding two sections of 24 in. pipe in the 550 mile oil line from Longview, Tex., to Norris City, Ill.

Fig. 2 (above)—A roll welded section on which finish welds are being made preparatory to bell-hole tie-in welding.

FIRST WELD on the world's largest oil-carrying pipe line, being built to help supply oil requirements of the East Coast, was made on August 3 by Williams Brothers, Tulsa, Okla. This firm is one of seven contractors who have been assigned the job of laying the 550 miles of 24 in. welded pipe all the way from Longview, Tex., to Norris City, Ill.

The line is being financed by the U. S. Government through the Defense Plant Corp. Its total cost is estimated at $35,000,000, and it is scheduled to be in service by the coming Christmas.

Arc Welding Employed

Extensive use of shielded-arc type welders and electrodes will be made throughout the length of this giant oil conveyor. The accompanying pictures, furnished by The Lincoln Electric Co., depict two stages of welding progress.

Fig. 1 shows weldors lining up and tacking two sections of the 24 in. diam seamless steel tubing. Clamps hold the pipe ends in alignment while the tack welds are made to assemble several lengths of pipe into a "string" for finish welding. The string is not too large to be rotated, so all the work of the firing-line gang, following the tack weldors, may be done in the flat position.

Tie-in Welds Difficult

In Fig. 2 are shown several lengths of pipe which have been "roll welded" as described into a long section. The next step will be the difficult "bell-hole" tie-in welding by which this string will be joined to the completed line. Bell-hole welds must be done in hard positions, with the pipe underground, and only highly skilled operators are permitted to make them.

Ditching operations are being conducted simultaneously with welding, so that as fast as the lengths of pipe can be welded into solid strings they will be placed in the ground and covered.

Each contractor will build a single section of the line, as follows:

(1) Williams Brothers, Tulsa, Okla., from Longview, Tex., to Texas-Arkansas state line.

(2) O. E. Dempsey Construction Co., Tulsa, from the state line to Gurdon, Ark.

(3) Anderson Brothers, Tulsa, from Gurdon to Little Rock, Ark.

(4) Oklahoma Contracting Co., Dallas, Tex., from Little Rock to Missouri-Arkansas state line (St. Francis River).

(5) C. E. Foreman Co., Kansas City, Mo., from St. Francis River to Illmo, Mo. (Mississippi River).

(6) Ray E. Smith Construction Co., El Dorado, Tex., from Mississippi River to Harrisburg, Ill.

(7) Sheehan Pipe Line Construction Co., Tulsa, from Harrisburg to Norris City, Ill. This firm has also been awarded contracts for construction of the 14 in. branch line from Norris City to Mt. Vernon, Ind., and for the 10 in. branch line from Norris City to Enfield, Ill.

Eight River Crossings

The main pipe line will cross the Red, Little Missouri, Ouachita, Arkansas, Cache, White, St. Francis and Mississippi rivers. Contracts for the construction of the eight river crossings have been awarded to Williams Brothers.

When completed, the line will deliver 300,000 bbl of East Texas crude oil each day in Illinois for transshipment eastward.

★ INSPECTION

Invisible radium radiation has been turned into a powerful tool for revealing defects beneath the surface of "good-looking" welds. No. 2 in a series on non-destructive tests.

Gamma-Ray Testing of Welds

By **CLYDE B. CLASON**

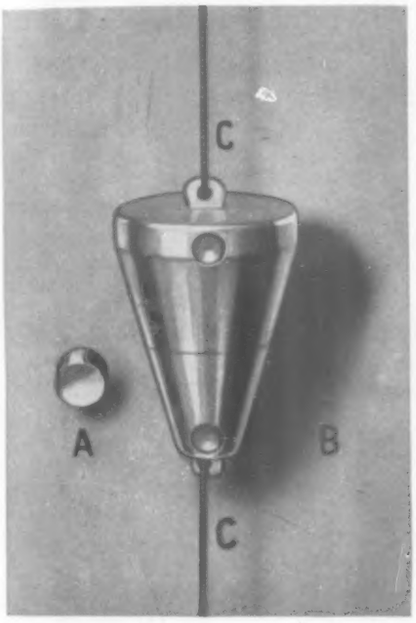


Fig. 1—Radium capsule (A) with egg-shaped duraluminum container (B). The container is handled by means of the cords (C) attached to its eyelets.

IN CONTRAST to X-ray radiography, radiography by means of gamma rays has been very nearly an all-American production. Present war problems make it highly appropriate to mention that the idea of using gamma rays for the inspection of welds and castings originated with a branch of our own armed services. This idea was the brilliant brain child of Dr. Robert Mehl, superintendent of the Division of Physical Metallurgy, U. S. Naval Research Laboratory, Washington, D. C. So well did he lay the groundwork for the development of gamma-ray technique that the rules issued by the Navy Department in 1934 are still the Bible of all good gamma-ray radiographers.

The First Gamma-Graph

Dr. Mehl, of course, did not discover gamma rays, nor did he make the first radiograph from them. The latter was produced as far back as 1896 and may be attributed to Henri Becquerel, closely associated with Professor and Madame Curie in the discovery of radium, who used a uranium compound to transfer the image of an aluminum medal to a photographic plate which had previously been wrapped in black paper and covered with aluminum foil.

Becquerel's pioneer gamma-graph closely followed and was perhaps inspired by Roentgen's discovery of X-rays in 1895. Thus the two big branches of industrial radiography are almost twins—if the fact is overlooked that one is of German and the other of French ancestry.

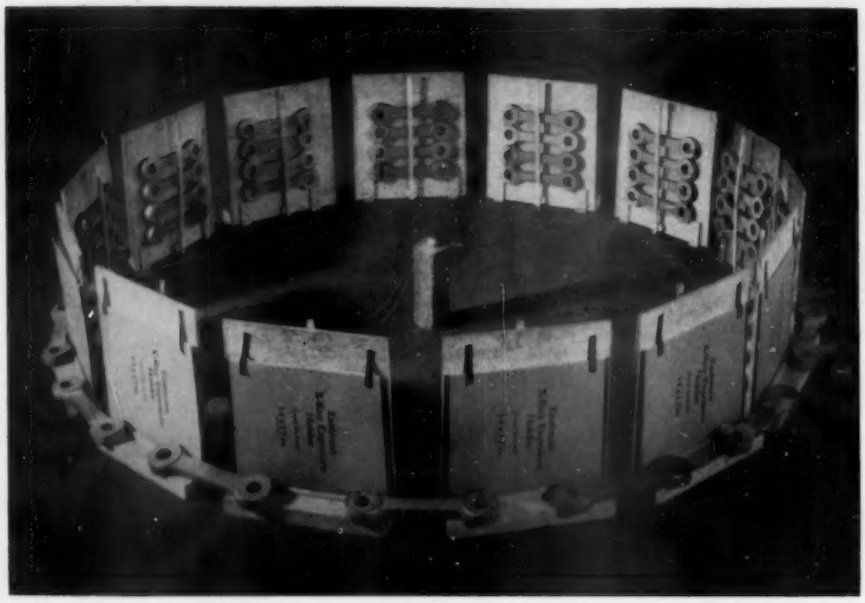
Though the laws of radioactivity were rather fully known early in the present century, nothing apparently was ever done about making use of radium industrially until 1925, when Messrs. Pilon and Laborde ascertained the extent of damage to the blades of a large marine steam turbine by means of a borrowed gram of radium. The radium, significantly enough, was borrowed from Dr. Henri de Rothschild—only a Rothschild could be expected to possess so vast a quantity of radium as one gram.

In 1928 Dr. Mehl conceived the idea of using gamma-ray photographs for viewing the interiors of thick sections of steel plate. Those wishing further particulars are referred to the scholarly paper presented by Charles W. Briggs at the first meeting of The American Industrial Radium and X-Ray Society, Inc., which was published in the Society's journal, *Industrial Radiography*.[1] Briggs was closely associated with Dr. Mehl at the Naval Research Laboratory, and he and R. A. Gezelius later took over this particular branch of work.

Another gamma-ray pioneer whose name should be remembered is Dr. G. E. Doan, associate professor of Physical Metallurgy, Lehigh University. In 1931 Dr. Doan presented before the American Society of Steel Treating and before the ASTM Symposium on Welding papers point-

[1] "Developments in Gamma-Ray Radiography 1928-1941," page 7, Summer, 1942, issue of *Industrial Radiography*.

Fig. 2—"Radium locating" stand in use for radiographing of a flange on a heavy casting. The radium is at the end of the "elephant's trunk" tube, and the films are arranged continuously so that the entire circumference of the flange may be radiographed at one time.



Photograph, courtesy Crane Co.

Fig. 3—Here 60 cast rocker arms are being simultaneously exposed to gamma rays from a single radium source. Note the circular arrangement of the castings.

ing out the advantages and applications of the then very new method of gamma-ray weld testing.

Gamma and X-Rays

Every bright schoolboy knows that gamma rays are one of three radiations from the element radium. Alpha and beta rays are corpuscular in character, but gamma rays are true electromagnetic oscillations with velocity equal to that of light. On the electromagnetic wave spectrum, gamma rays range from .01 to 1.4 Angstrom Units, while X-rays range from .06 to 120 Å. Thus there is a certain amount of overlapping. It is owing to their almost inconceivably small wave-lengths (1Å = 1/100,000,000 cm) that both gamma rays and X-rays possess the power of penetrating apparently solid objects which are opaque to all forms of visible radiation.

Gamma rays, being the shortest, are able to penetrate the farthest. Up to 11 and 12 in. of steel have been traversed by gamma rays as compared to the present record of approximately 8 in. for the million volt X-ray machine.[2] However, gamma rays require considerably longer time for penetration. Theoretically, it is possible to generate "hard" X-rays with penetrating power equivalent to gamma rays, and perhaps this will be realized in the not too distant future. Meanwhile, radium capsules serve as extremely efficient ray sources, costing nothing for outside power and requiring very little trouble or attention.

[2] "X-Ray Testing of Welds," page 31, THE WELDING ENGINEER, August, 1942.

Radium Disintegration

Radium is spontaneously transformed into other elements at a rate which may be expressed as a logarithmic function of the time involved. No physical or chemical means known to man is capable of either hastening or slowing down this process. The half-life period of radium has been computed as 1,580 yr. This works out as an annual loss of 0.04% —which trifling quantity may be neglected in most calculations of radium intensity. The first product of radium disintegration is a gas, radium emanation or radon, which has a half-life of 3.85 days. Either radium salt or radon is applicable to industrial radiography, but radium salt is more common and is greatly to be preferred as the short half-life of radon necessitates complicated corrections in exposure time estimates.

The insoluble sulphate is the radium salt generally employed for industrial radiography. The quantity of radium present in a capsule is expresed in milligrams, the figure stated referring to the weight of actual radium element present and not to the weight of the salt. To clarify, one mg of radium sulphate contains 0.7017 mg of Ra, and, conversely, 1.000 mg of Ra are present in 1.4250 mg of radium sulphate.

The radium salt is sealed in an airtight silver capsule as the radon being continually produced from it is an extremely dangerous gas and would cause death if anyone breathed even a minute quantity. After a period of about one month, there is reached within the sealed capsule, a "state of equilibrium" in which radon is formed as fast as it disintegrates into the next transformation product. Once the amount of radon has become constant, the radiating strength of the capsule is exactly proportional to the quantity of radium it contains. Though this quantity is continually lessening, the rate of change is, as we have seen, extremely small and may be overlooked in short-term calculations without appreciably affecting the result.

To guard against accidental crushing, with consequent liberation of the highly toxic radium emanation, the silver capsules are placed within ovoid containers (Fig. 1) of either aluminum alloy or steel. Such a container is not a shield against radium rays and should not be directly handled, even with gloves, but should be manipulated into position by means of strings or with a magnetic handling rod.

Fig. 2 shows a special "radium locating" tube-stand. The base is on locking casters, and the 6 ft horizontal arm may be raised, lowered, rotated, withdrawn or extended. At the end of the arm is an "elephant's trunk," a copper tube through which the radium container is pulled by the strings attached to its eyelets. With this device, the radium may be readily located in any desired position and held without vibration, and the radium container is never handled directly at any time.

Other Safeguards

A lead-lined portable carrying case is used for transporting the radium container to the work. When not in service, the radium should be stored in a vault or safe that is heavily lined with lead. These and other safety precautions are essential because of the danger of radium burns.

An X-ray or gamma-ray burn is not only more difficult to treat than an ordinary fire burn, but it is also more painful. While the danger of a burn is proportionate to the length of time the person has been exposed to the radiation, the problem is greatly complicated by the fact that exposures to gamma rays are, to a certain extent, cumulative. Hence, it is as bad to be exposed every day for short periods of time as it is to be exposed for a long period on a single day.

These cumulative effects, fortunately, may be detected by photographic film. Everyone who works daily with radium should carry with him a light-sealed packet of X-ray films, which are to be developed at intervals of a week or so. If the film has been markedly darkened, the radium

handler is in danger and should be transferred to another line of work for a while. Exposures separated by comparatively long periods of time, say several weeks or a few months, are not cumulative.

The best shield against radium is distance. As the distance increases, the intensity of the radiation drops off to accord with the well-known inverse square law. The Bureau of Standards Handbook[3] lists safe distances as 3 ft for a daily exposure of 100 milligram-hours, 4 ft for a daily exposure of 200 mg-hr, 6 ft for 400 mg-hr, 8 ft for 800 mg-hr, 11 ft for 1,600 mg-hr and 15 ft for 3,200 mg-hr. If proper precautions are observed, it is no more dangerous to handle radium than to walk with a green light across the traffic of a busy street corner.

Radiography with Radium

The manner in which X-rays darken a photographic film to produce a "shadow picture" was fully explained in the article, "X-Ray Testing of Welds," August, 1942, issue of THE WELDING ENGINEER. Gamma rays produce similar effects but require appreciably longer exposure times.

Standard X-ray films are in general use, though a new high-speed film especially developed for gamma rays is now available. The film holder or cassette may be either hard-backed or flexible, the latter type being used when it is desirable to have the film conform to the shape of the object being radiographed, as in Fig. 2. The films, naturally, are placed on the opposite side of the object from the radium.

To secure a sharp image, the film should always be placed as close as possible to the object being radiographed. On the other hand, decreasing the focus-film distance (distance between radium capsule and film) will also decrease image definition. For optimum results, a comparatively long distance from film to radium is desirable, but this will necessitate either a large radium source or a long exposure time. Thus it may be seen that the problem is chiefly one of effecting a satisfactory compromise.

For a source of 100 mg, U. S. Navy Department specifications for gamma-ray radiography establish minimum focus-film distances of 8, 10 and 17 in. for steel thicknesses of 1 in., 3 in. and 4 in., respectively. For a source of 250 mg, these minimum distances are increased to 10, 12 and 20 in., for the same thicknesses. For 25 mg, they are lowered to 6, 9 and 15 in.

The capsule radiates gamma rays spherically; i.e., in all directions with equal intensity. Hence, several objects may be examined at once with the same radium source by arranging them in a circle around the capsule. Fig. 3 is a very good illustration of how this may be accomplished. The radium may also be placed within a cored casting, as in Fig. 2, and radiographs taken on all sides simultaneously.

Determining Exposure Time

One of the major problems confronting the radiographer is the calculation of the proper exposure time. This is a function of several variables: film-to-source distance, milligrams of radium in the source, the thickness and density of the material being examined.

Charts, tables and slide rules galore have been developed to simplify this problem. One of the most useful of these calculating devices is the Naval Research Laboratory's circular slide rule (Fig. 4), on which may be read the correct exposure for steel with any given radium source, thickness of material and focus-film distance in a practicable range.

To obtain the exposure required for any metal other than steel, it is necessary to take into account the density of that particular metal. Table I gives the density or specific gravity of various metals expressed as percentages of the specific gravity of steel, 7.84. For any desired metal, it is only necesary to multiply the thickness in inches by the figure given in the table; then the product is the corrected thickness for use in an exposure table or chart based upon steel. For example, suppose an aluminum plate 5 in. thick is to be radiographed; 5 x .342 = 1.710, which means that 5 in. of aluminum is equivalent in density to no more than 1.71 in. of steel. Conversely, 5 in. of brass will be found equivalent in density to 5.30 in. of steel.

Table I. Specific Gravity of Metals as Percentages of the Specific Gravity of Steel, 7.84.

Metal	% of Steel
Aluminum, pure, rolled	34.2
Brass (67% Cu, 33% Zn), cast	106.0
Brass sheet	107.5
Bronze (90% Cu, 10% Sn)	110.5
Bronze, Tobin	107.0
Chromium	87.5
Copper, cast	110.9
Copper plates and sheets	113.9
Copper wire	113.0
Iron, cast grey	90.4
Iron, cast, pig	91.9
Iron, wrought	98.0
Lead, cast	144.8
Lead, sheet	145.8
Magnesium	22.3
Monel metal	113.0
Nickel, cast	105.4
Nickel, rolled	110.7
STEEL	100.0
Tin, cast	93.6
Zinc, cast	87.5
Zinc, rolled	91.6

Intensifying Screens

Navy specifications require the use of lead intensifying screens of approximately 0.006 in. thickness; these thin lead sheets are sandwiched between the films of a cassette in a lead-film-lead-film-lead arrangement. The purpose of the screens is to retard

[3] Handbook H23, "Radium Protection," National Bureau of Standards, U. S. Department of Commerce, page 6.

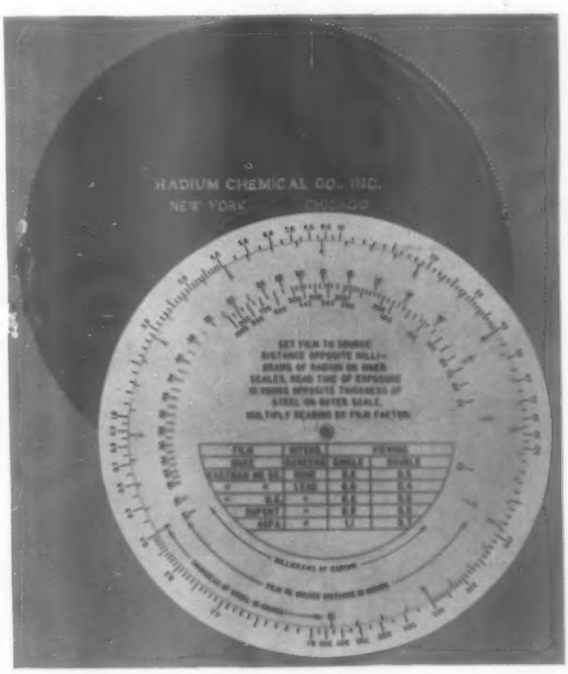


Fig. 4 — Navy-type circular slide rule with leather carrying case. Radium source (mg) is set opposite film-to-source distance (in.), and the exposure time (hr) is read opposite steel thickness (in.) on outer scale. If necessary, reading is multiplied by the film factor given in the table.

the passage of direct rays through the film emulsion. This has the same effect as an increase in the intensity of radiation would have, making for increased contrast on the film negative and decreased exposure time. All exposure tables and calculating devices are based on the use of lead screens — an important point for radiographers to remember.

Navy specifications also require the use of identification markers. These, it is stated, "shall be placed on the film side of the casting in such a manner that the image will appear on the radiograph. The location of these markers shall be accurately and permanently stamped or stenciled on the metal surface in order that the orientation of the radiograph may be established and the defects indicated on the negative accurately located in the object radiographed. Where such stamping or stenciling is impracticable the outline of the cassette may be painted on the object radiographed with sufficient permanence that it will be available as long as necessary in the repair of defects and the location of films for radiographing repairs."

Identification numbers and letters as they show up on gamma-graphs will be found in Figs. 5 and 6.

Use of penetrameters is specified in codes for the inspection of boiler and pressure vessels. A penetrameter is a sensitivity gauge, defined by the Navy Department as "a strip of metal the radiographic density of which is the same as that of the metal being tested, of suitable thickness and provided with a combination of steps, holes or slots. When placed in the path of the rays, its image provides a check on the radiographic technique employed."

Weld Defects Revealed

Porosity, slag inclusions, lack of fusion and cracks are the common welding faults which are revealed by the all-seeing gamma rays. The accompanying gamma-graphs illustrate some of these defects.

All of the welds pictured in the radiographs, Fig. 5, 6, 7 and 8, were made on the seams of pressure vessels. The Hamler Boiler & Tank Co., from whose files the gamma-graphs were borrowed, uses both manual arc welding and automatic (submerged melt) welding processes. Gamma-graphs are made on all welds which are to be subjected to high internal pressures, in accordance with ASME Boiler Code and other code requirements. Radiographs with gamma rays are also taken frequently as a test check on other welds—and on the weldors.

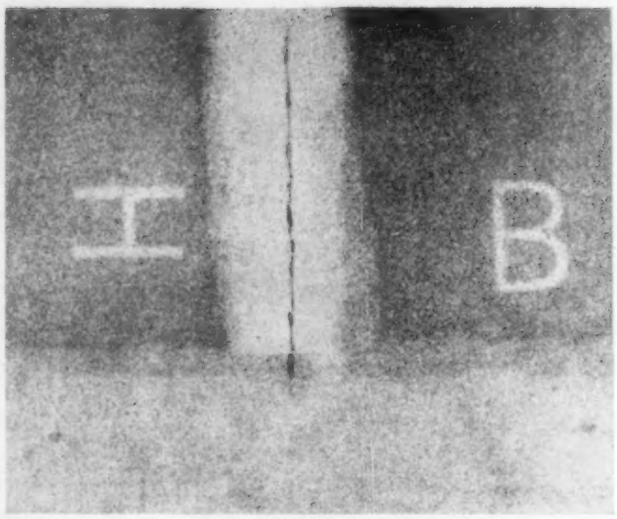


Fig. 5—Lack of fusion, indicated by dark vertical line. This gamma-graph was taken at a point where a longitudinal seam runs into a circumferential seam of a welded pressure vessel. Note images of lead identification numbers.

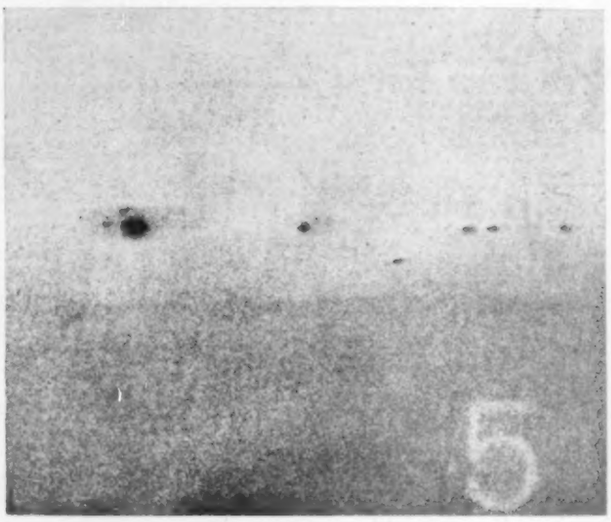


Fig. 6—Entrapped slag (black spots) from a manual arc weld made to back a Unionmelt weld. The slag drifted up into the Unionmelt as automatic welding progressed.

Fig. 5 is the intersection of manual arc welded longitudinal and circumferential seams. The long dark line (vertical in this cross-section of radiograph) indicates a pronounced lack of fusion.

Figs. 6 and 7 were selected as representatives of that fairly large class of welds which are weakened by slag inclusions. Fig. 6 is particularly interesting. Here the slag is from a manual arc weld which backed up a Unionmelt automatic weld. The slag gradually sifted up into the Unionmelt as the automatic welding progressed.

Fig. 8, introduced for a comparison, is of a weld without a flaw. Uniform density of weld metal is indicated by the nearly unvarying tone in the lighter area.

Gamma-Ray Advantages

Gamma-ray radiography has many advantages. Foremost among these is its portability. Two not-very-large boxes, one for radium and the other for films and film holders, contain all equipment necessary to do a complete job. This makes it possible to test welds right in the field, in location to which more bulky equipment could not possibly be transported.

The small size of the radium capsule permits its use in many unusual places and positions. It can, for example, be suspended deep within the interior of a small pipe by means of the "fish-line" attached to the container. The radiographing of several objects simultaneously and the radiographing of opposite sides of hollow objects at the same time have already been mentioned.

The penetrative quality of gamma rays is another important advantage. Though 10 in. of steel is usually taken as the effective limit, it is reported that sections of steel up to 12 in. in thickness have been radiographed by this method.

Ideal Power Plant

No more ideal "power plant" than a radium capsule could possibly be imagined. It burns no outside fuel,

Fig. 8—A very good manual arc weld. The nearly unvarying tone in the lighter area indicates a uniform density of metal.

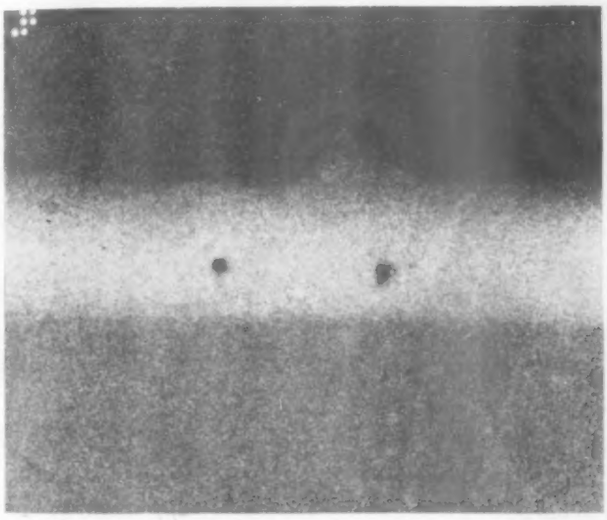


Fig. 7—Slag inclusions (dark spots) which rendered a manual arc weld inacceptable. The slag had to be chipped out and new weld metal deposited.

requires no attention nor maintenance, operates continuously for 24 hr of every day and will keep going forever—at least as far as short-lived human beings are concerned. Moreover, the initial investment or monthly rental cost is virtually the only expense.

Radium for industrial radiography may now be readily obtained from reliable radium supply firms. Because of its high cost (about $23 per mg), it is usually rented instead of being purchased outright. It may be rented by the month or year at rates which are extremely moderate when compared with those prevailing only a few years ago. A capsule containing 100 mg can be secured for $25 a month on a yearly lease basis (straight monthly rental a trifle more), and 25 mg can be rented for around $8 a month.

Though radium is, of course, well insured, the danger of theft is not nearly so great as is popularly supposed. A stolen capsule cannot readily be sold because any radium sale necessitates certification at the National Bureau of Standards. The American Medical Association also keeps radium records. Tampering with the capsule in an attempt to alter its identification markings is an exceedingly dangerous proceeding; it is probable that the thief who did this would be so marked that he could be picked out of a thousand men. If the thief actually opened the capsule, either deliberately or accidentally, he would probably die very painfully.

X-Rays Faster

As compared with X-rays, gamma rays have two specific radiographic advantages. One is their higher penetrating power, and the other is lack of "scatter." With gamma rays, it is not necessary to use such shielding devices as the Bucky grid in order to prevent the film from becoming fogged by stray or secondary radiation. But X-rays also have two important radiographic advantages over gamma rays; namely, speed and sensitivity.

With regard to speed, there can be little argument. X-ray exposures are a matter of seconds or minutes, gamma-ray exposures of hours. Gamma rays just aren't in the running if extreme haste is indispensable. On the other hand, it is often a convenience to be able to arrange object, radium source and film in position and leave them together all night long without attention from anyone.

X-rays are also more sensitive, particularly on thin plates. In steel less than 2 in. thick, X-ray sensitivity is about 0.5% of the metal's total thickness. Gamma rays will not reveal such fine defects, being unable to detect flaws of thickness less than 2%. For this reason, gamma-ray testing is rarely used for steel under 1 in.

The difference in sensitivity between gamma and X-rays tends to lessen as sections become thicker. For steel of 2 to 4½ in., both types of rays are able to reveal flaws with magnitude of around 2%. Until recently, gamma rays had the field of plates over 4½ in. all to themselves, but the million volt X-ray machine has now encroached considerably upon this territory.

X-rays are unquestionably best for radiographs of comparatively thin plates of nearly uniform thickness, but the lesser sensitivity of gamma rays can at times be a decided advantage. This is true when examining objects of varied or irregular thickness. For such objects, it is necessary to set for an average thickness, and X-rays, if the differences are at all great, are likely to "burn out" the negative at the thin parts of the object and materially under-expose the thickest portions. Gamma rays, on the contrary, are much more likely to give a "readable" radiograph everywhere.

Not Competitors

In considering the comparative advantages of X-rays and gamma rays, the main point to be remembered is that they are not competitors. Each method is well suited to its own particular field and specific tasks. The user of radiography should not waste time weighing gamma rays against X-rays with the idea of eliminating either one or the other. Instead, he should consider how one method may be used to supplement the other in doing the job he has at hand. Both methods are needed — today more than ever.

* * *

Acknowledgment is made to the Radium Chemical Co., Inc., and to the Hamler Boiler & Tank Co., Chicago, for permission to reproduce the photographs shown here.

All-Welded Steel Hotel

Since the Halls of Montezuma, there probably never was a more imaginative design for any building than this truncated star.

ACCORDING to opinions of leading architects, the Canadian Lake Louise Hotel was the most unique all-welded steel building ever constructed. It was built in the form of an eight-pointed star (Fig. 1) with one ray missing to allow for the front entrance. Walls, roof and central dome were made from 12 gauge mild steel plate, pre-fabricated on the site into panel sections.

30,000 Lb of Electrodes

Luckily, this job was finished prior to the steel scarcity in the United States and Canada. Over 250 tons of steel were needed for the 1,270 roof panel sections and 1,125 wall panels required. Thirty thousand lb of mild steel electrodes were used to make 12.7 miles of welds. Twenty 200 amp arc welders were employed.

A crew of 20 weldors and 20 set-up men completed the big job in six weeks. Advantages of arc welded construction, according to John F. Dillon, Jr., welding engineer on the project, were: (1) ease of construction, (2) low initial cost, (3) low maintenance costs, (4) short construction time, (5) a fireproof, termiteproof building, warm in winter, cool in summer.

Each ray section of the hotel was 125 ft long, 32 ft wide, 9 ft 4 in. high. The center dome, 100 ft in diameter, had no central supports.

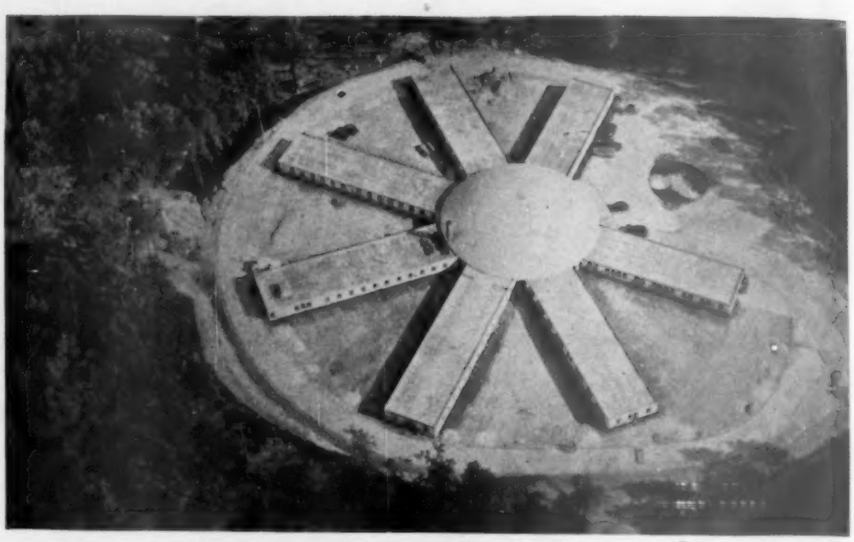


Fig. 1—Aerial view of Canadian Lake Louise Hotel showing its star-shaped form. Front entrance is at right. There are 70 rooms in four wings, dormitories in two, dining hall and kitchen in the seventh. The 100 ft diam dome has a seating capacity of 1,600 people.

It consisted of regular panel sections staggered in welded rows. Fig. 2 shows the method of construction. A special jig, consisting of a center pole with swinging boom, was used to place the dome panels and to support a platform for overhead welding on the inside of the dome.

Forming the Panels

Roof and wall panels were fabricated on the building site. Another special jig, containing magnets, was used to hold the sheets apart while the cross-braces for the panels were tack welded. Roof panels were 46 in. wide, 92 in. long, 18 in. deep. Wall panels were 46 in. wide, 92 in. long and 6 in. deep. Sixty tons of insulation were put into the walls and ceilings.

The floor was made from reinforced concrete 6 in. thick. Junior 6 in. I-beams were used on the outside of the concrete and also across the concrete for welding the wall panels to them and for expansion joints.

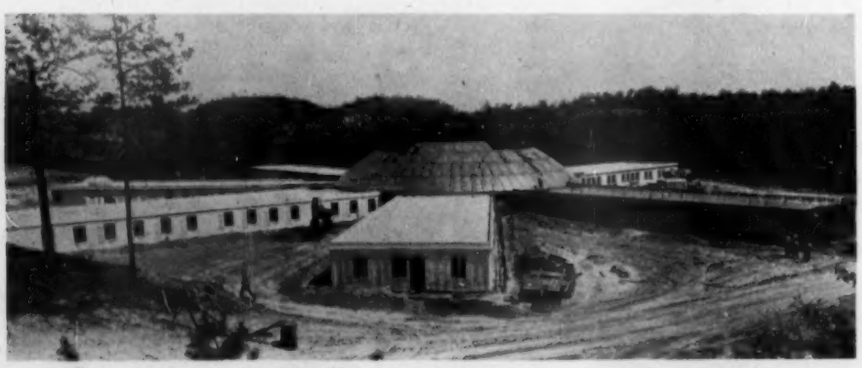


Fig. 2—Construction of dome, which consisted of panel sections staggered in welded rows. By close observation the jig for erection of the panels can be seen in the center of dome. Note ditches on each side of each wing for water, steam and sewage pipe lines.

Piping Brazed

All pipes—water, steam and sewer—were joined by brazing. Main feed lines were put around the lobby section. Down each side of the wings, on the outside, ran four feeder lines which supplied hot and cold water, steam heat and handled sewage. These lines were put into an underground box and separated from each other by insulation.

* * *

Acknowledgment is made to Hobart Brothers Co., Troy, O., for the photos accompanying this article.

Fig. 1—In engine room piping installations, welded fittings make possible a neat, compact arrangement of the various steam, water and oil lines of a ship.

Welded Ship Piping

By T. B. JEFFERSON

Modern demands, war production demands both call for simplicity of construction which must be coupled with safety. If a saving in material also results, an immediate approval can be expected.

SIMPLICITY and weight savings are the features which have led to the extensive use of welded piping in modern ship construction. While the piping systems in the engine rooms of large ocean going vessels differ very little from the piping systems of the modern central station, the welding of this piping offers definite advantages aboard ship.

The principal concern of the naval architect and his associates engaged in the design of a ship is to reduce the weight of auxiliary equipment. A reduction in weight of the auxiliary equipment of a ship does not affect the safety of the ship's operation, yet every pound reduction in weight means the cargo capacity may be increased a pound.

Welded Piping Weighs Less

This brings up the question: "How can the welding of ship piping reduce weight?" Welded piping will reduce weight much in the same manner that any type of welding will reduce weight if the design is correct and there is no desire to increase the strength of the member that is to be formed by welding. The weight saving in welded pipe construction is derived from two sources:

(1) The elimination of "lap joints" such as will be obtained when a pipe is screwed or flanged to fittings;

(2) The lighter weight of the forged or fabricated weld fitting as compared to the heavier cast steel or cast iron fitting.

An idea of the weight saving made possible by the use of weld fittings instead of flanged fittings may be obtained by consulting Table I.

Neat Installations

Another factor in favor of welded piping installations aboard ship is the neatness and compactness of this type of construction. Welding makes it possible to run the pipes closer to the bulkheads, to swing in, out and around obstructions with greater ease, to install branches and connections where most convenient, even in next to impossible locations. A pipe closer to a bulkhead means more room for the cargo, while conveniently located connections eliminate the use of unnecessary pipe.

Table I—Comparative Weight of Pipe Fitting

Fitting	125 psi Service Weight		250 psi Service Weight	
	Cast	Welding	Cast	Welding
4 in. 90° Elbow	68	13	105	18
4 in. 45° Elbow	71	8	117	11
4 in. Tee	92	16	145	20
4 x 3 Reducer	60	6	96	8
8 in. 90° Elbow	168	60	286	90
8 in. 45° Elbow	188	34	326	55
8 in. Tee	233	65	396	83
8 x 6 Reducer	148	15	253	21

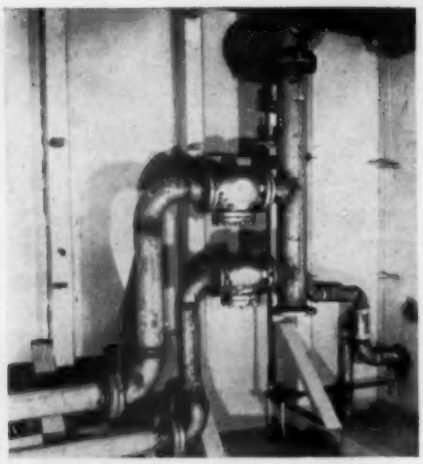


Fig. 2—Flanges are occasionally welded in line to facilitate the removal of valves and other special fittings.

Compact installations and the savings in cargo space they provide are becoming increasingly important. It is essential that a minimum of cargo space be allotted to piping and auxiliary equipment; this requirement is readily met in welded pipe installations. At the same time, welded joints are strong and remain permanently tight, even under conditions of extreme vibration.

Pipe 70% Welded

The amount of welding done in connection with a ship piping installation varies according to the shipyard. In the Gulf Coast yards of the Ingalls Shipbuilding Corp. approximately 70% of the piping installed is all welded.

On these all-welded lines, all of the fittings are welded into the line, with weld flanges being used where it is necessary to have flanges for the removal of valves or where the piping is connected to various pieces of machinery, such as pumps, condensors, tanks, etc. About half of the remaining pipelines aboard the ship are welded to some extent. It might be said, in fact, that from 80% to 85% of the piping system in an Ingalls built ocean-going ship is welded.

Safety Also Important

Welded piping, however, is not installed only because of its simplicity, lesser weight and neatness. Safety, too, is of the utmost importance! The failure of a high pressure, high temperature steam line in the boiler room of a ship may result in much more serious consequences than a similar failure in a power plant. Hence, ship piping installations are subjected to many very rigid requirements to insure their safety.

On some of the high pressure steam lines, particularly the gage lines in the engine room, welding is used as a safety measure. These pipes are joined by means of screwed high pressure fittings, but, after they have been made up tight, a sealer bead of weld metal is run around the fitting. Though intended primarily for the purpose of fastening the fitting to the pipe, this weld bead also serves to seal the thread joint, eliminating any possibilities of leaks.

Welding in ship construction is rigidly controlled and carefully inspected. The type of ship to be built determines who is to supervise the inspection. The American Bureau of Shipping is the inspection body which formulates the rules for the Maritime Commission Ships; i.e., the C-1, C-2 and C-3 class ships and the popular "Liberty" type or EC-2 emergency ship. It is the ABS rules (also rules of the U. S. Coast Guard Division of Marine Inspection and Navigation) that regulate and determine the conditions which must be met in welded ship construction, including the installation of welded pipings.

Ship Piping Standards

The operating temperature or pressure of a particular service line is the governing factor in the classification of ship piping. So that definite standards might be established the American Bureau of Shipping has classified ship piping installations as shown in Table II.

The major difference between the inspection requirements of Group I and Group II piping installations is the necessity of a non-destructive examination of the weld seams on Group I pipes. This inspection may be made either by radiography or magnetic powders. For both groups, approval must be obtained on (1) the welder, (2) the procedure and (3) the electrode.

Welding on ship piping of either Group I or Group II classification must be done with weldors who have been qualified by either the American Bureau of Shipping, The Navy Department, U. S. Coast Guard or the Bureau of Marine Inspection and Navigation. By a recently concluded agreement, a weldor qualified by one of these four bodies is acceptable to the others.

The welding procedure to be used in pipe welding is based upon its demonstrated suitability to the particular construction involved. When new methods, changes in base material or electrodes are proposed, it is necessary to obtain new procedure approval. This is accomplished by testing specimens prepared under the new conditions from materials similar to those proposed for the pipe construction.

Table II. Ship Piping Classification*

	GROUP I		GROUP II
Medium	Pressure or Temperature		
Steam	100 psi	350 F	Any medium of Group I with pressures or temperatures below those for Group I.
Water	150 psi	200 F	
Oil	150 psi	150 F	

*ABS regulations. Ships must also pass the Bureau of Marine Inspection and Navigation regulations, which are somewhat more restricting.

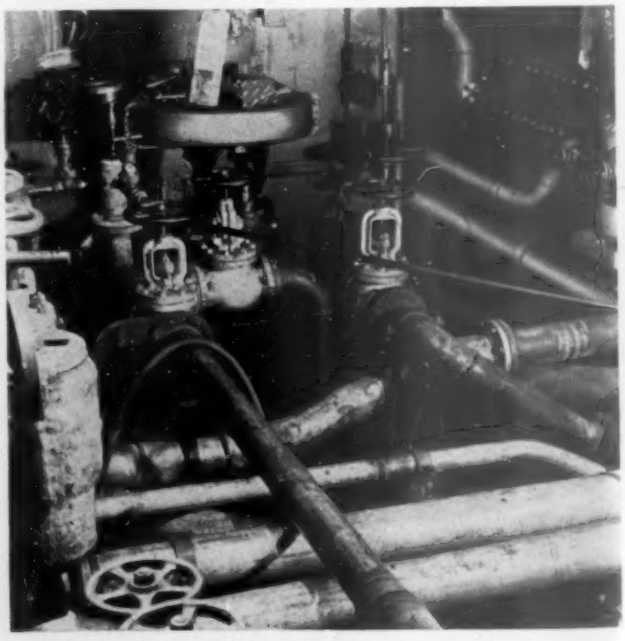


Fig. 3—In the engine room it is frequently found convenient to heat and bend the pipe rather than to weld in fittings to obtain the desired offset.

In the case of arc welding, the electrodes to be used must be approved.

Use Both Welding Methods

Both gas and arc welding are used in the fabrication of ship piping, as may be seen from Table III. Pipe size is usually the determining factor in the selection of the welding method to be used. In the Ingalls yard the usual practice is to use oxy-acetylene welding for pipes under 3 in. diam and arc welding on pipes over 3 in.

Pipe size is not always the determining factor. In other ship yards, it was found that the welding process to be employed was determined by the wall thickness of the pipe. In these yards, the usual practice was to permit oxy-acetylene welding on all classes of pipes with wall thicknesses of $\frac{1}{16}$ in. to $\frac{3}{16}$ in., inclusive, while restricting arc welding to pipes having a wall thickness of $\frac{3}{32}$ in. or more.

Table III. Welding for Ship Piping

System	Arc	Gas
Auxiliary steam exhaust	x	
Atmospheric exhaust (escape pipe)	x	
Boiler feed	x	
Sanitary system	x	
Free water feed lines	x	
Air vapor and feed vent pipes	x	x
Steam and out		x
450 psi steam	x	x
180 psi steam	x	x
50 psi steam	x	x
30 psi steam	x	x
Soot blower		x
Boiler blow down		x
Continuous blow down		
Fuel oil service	x	
Fuel oil transfer	x	
Bilge and ballast	x	
Heat coils		x
Sounding tubes	x	x
Ventilation and air exhaust	x	
Fire mains	x	
Deck drains	x	
Plumbing drains	x	
Steam returns	x	

In general, it has been found that the cost of joints welded by the oxy-acetylene process is somewhat higher than those arc welded. Nevertheless, oxy-acetylene welding is generally used on small diameter pipes because the quality and appearance of the oxy-acetylene welded joint is usually more uniformly satisfactory. This might be attributed to the fact that the oxy-acetylene method is somewhat slower than the arc and therefore offers a better opportunity to control the volume of weld metal deposited and the contour of the weld bead.

Thin-Walled Pipes Difficult

One of the principal disadvantages of oxy-acetylene welding of piping is the possibility of overheating the base metal, particularly in pipes with thin walls. Overheating, in this instance, causes an undue grain growth beyond the fusion zone and tends to embrittle the joint. On the other hand, in the arc welding of thin-wall piping, considerable difficulty has been experienced in producing tight joints. This is primarily due to the failure of the weldor to develop a procedure that will completely eliminate craters, inasmuch as porosity is usually found at the points where welds are either started or finished.

About the only other precaution necessary in the welding of piping is the determination of the minimum space required for the welding of joints in the fixed position. If pipes are run too close to bulkheads or other obstacles, it has been found, the weldor may possibly experience difficulty in making a sound weld.

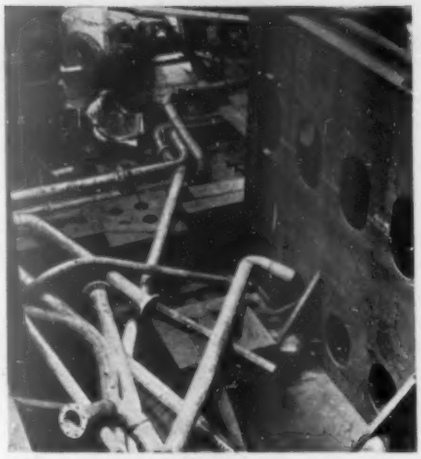


Fig. 5—In this view of a ship under construction it will be noted many lengths of pipe are fabricated in the shop prior to installation.

In addition to oxy-acetylene and arc welding, pressure thermit welding is sometimes used in connection with ship piping. This application, however, is usually limited to extremely thick walls of high pressure pipes.

Ferrous and Copper

The demands placed upon the skill of the pipe weldor may best be determined by considering the various materials he is called upon to weld. Most of the piping aboard ship is of the black iron variety, but there are installations of wrought iron, stainless steel, bronze and Monel piping as well.

All of the piping in a modern ship, however, must not be thought of as being of steel or wrought iron. Many pipes, particularly those handling raw sea water, are copper. It will be found that copper, brass and bronze and copper-nickel alloys are usually employed where protection against corrosion is required.

For some applications, the copper pipe may be as large as 24 in. in diameter. It is generally found most advantageous to form pipes of such large sizes from copper plates, and this work is usually a coppersmith's job. The longitudinal seams are closed by either forge or gas welding, while flanges are brazed into place.

Irrespective of the job, welded piping is definitely contributing to our Victory program, for it is the welding of pipes and ships that makes it possible to increase the merchant marine at the 3-ships-a-day rate.

* * *

Acknowledgment is made to Tube-Turns, Inc., Louisville, for the piping installation pictures accompanying this article.

Fig. 4—The use of welded fittings in pipe construction makes it possible to arrange the pipes close to one another as well as close to the bulkheads in the ship.

Maintenance at a Gold Mine

The world's largest gold recovery plant has found welding and cutting an important means of maintenance and construction. The cost of these operations is kept to a minimum by the use of scrap material.

The mill management is fully convinced that arc welded construction is the most economical approach to problems of maintenance. Maintenance equipment includes seven arc welding machines. Three-phase power is supplied with outlets throughout the mill to facilitate the hooking up of a welder and running of a relatively short welding cable to a job any place in the mill.

Use Scrap Materials

One of the most interesting features in arc welding work done by this mill has been in using scrap materials for construction purposes. Old structures, pipe lines, tanks, etc. are salvaged from their own properties or bought low cost from other sources. Equipment of all types is fabricated from this scrap material.

NATURALLY, there is considerable wear and tear due to abrasion and corrosion in the plant of the Golden Cycle Corp., Colorado Springs, Colo. It is said to be the largest custom mill using the cyanide recovery process in production of gold! This mill, which obtains gold ore from mines in the Cripple Creek and other districts west of Colorado Springs, has a daily capacity of 1,500 tons.

The job of extracting gold metal from this rock-like ore is one which requires an elaborate lay-out with a large amount of processing equipment. Efficient operation requires the constant attention of the maintenance department. Moreover, there is the problem of continually modernizing and expanding the mill facilities, which requires construction of containers, structures and special processing equipment of all kinds.

★

Fig. 1 (above)—View beneath the sand-leaching tanks, Golden Cycle Corp., Colorado Springs. A number of these 50 ft diam tanks were rebuilt, using welded steel construction to replace the former timber supports.

Fig. 2 (right)—Close-up of diagonal brace of the pipe supports shown in Fig. 1. This brace was built of scrap pipe.

★

Photos by The Lincoln Electric Co.

Fig. 3—Welding a trough connection under the leaching tank. This trough carries away mill tailings after gold has been extracted by the cyanide process.

Fig. 1 is a view underneath the sand-leaching tanks. There are twelve 50 ft diam steel tanks in the cyanide leaching department. A number of these tanks have been recently rebuilt using welded steel construction; the former timber supports have been replaced with a foundation comprising 6 in. pipe supports and 15 in. I-beams, cross-braced by 7 in. channels. The pipe supports are welded at the bottom to ⅜ in. plates which are tied into the concrete foundation blocks by bolts. The entire foundation system is braced by diagonals running from the bottoms of some of the pillars to the I-beams at the top. These diagonal braces are 6 in. pipe. See Fig. 2 for interesting construction details of one of these diagonals built of scrap pipe. To increase their rigidity, all of the pipe supports and diagonals are filled with concrete after welding is completed.

A weldor may be seen fabricating a trough connection under one of the leaching tanks in Fig. 3. This trough carries sand and mill tailings away from the leaching tank after the cyanide process has been completed and all gold-bearing material removed. The trough was built from 16 gauge scrap iron.

Jaw Crusher Hard-Faced

In Fig. 4, W. E. Warner, welding foreman, points out the use of hard-facing for the kidney of a jaw crusher. The part is used in crushing ore, just before the ore goes to the cone crushers. In this operation the kidney is subjected to severe batter and abrasion along the bottom edge (top edge in illustration). This kidney is 36 in. wide and about 6 ft. long.

The chile mills shown in Fig. 5 treat ore in a somewhat different manner. These take ore in a fairly fine state and pulverize it so that the free gold can be collected on wool mats without having to be put through the cyanide treatment with the remainder of the ore. In this operation the ore is crushed by revolving rolls which travel on top of a die. The abrasion and batter causes the roll tires to wear very rapidly and makes necessary a continuous program of rebuilding and hard-facing by welding.

Other Applications

While the gold recovery system is in constant need of welding as a means of maintenance, there are frequent welding applications in other departments of this huge gold producing plant. A recent application has been a new boiler house (Fig. 6) which is of all-welded construction. This includes the house for the

Fig. 4—Hard-facing added to the kidney of a jaw crusher. The bottom edge (top edge in picture) is subjected to severe batter and abrasion.

Fig. 5—The chile mills. Tires of these revolving rolls wear very rapidly and must be continually rebuilt and hard-faced by welding.

stoker and boiler, stairway, railing, bases for blowers and motors, etc. The stairway is built from 6 in. channel stringer members with 1 in. steel pipe for treads. Treads were formed by welding four pieces of pipe to supports made of 2 in. by 2 in. angles, which in turn were welded to the stringer channels. All of this material was scrap—even the 1 in. pipe for the stair treads. Where necessary, pieces of scrap are welded together to provide pieces of sufficient length.

In Fig. 7 is shown a new pulverized coal collector and blower located in the power plant. This system was just being installed when photographed. It will work in conjunction with five coal pulverizers and will blow the pulverized coal through a system of 6 in. pipes to eight roasting ovens. The collector is 5 ft. in diameter. It was built from ¼ in. plate and has outlets for the pipes feeding the roasting ovens. A fan is mounted on the inside of the collector and is driven by a motor installed on top of the collector. The fan forces the pulverized coal through the pipes. This entire system is all welded construction, comprising scrap pipe and plate.

Welded Scrap Iron

The hot air duct shown in Fig. 8 is a part of the coal pulverizing system. It is built entirely from pieces of scrap iron welded together. The duct, which is not yet painted, shows the pattern of the various pieces of scrap as they were fitted together to form this structure. Similar methods of construction are used to a great extent throughout the mill.

Fig. 9 pictures a portion of the conveyor framework in sampler house. This conveyor feeds the crusher. It is typical of welded conveyor frameworks throughout the mill. The side members are 6 in. channels. Main supports are 6 in. pipe with 3 in. pipe for cross members and diagonals (see background). Intermittent supports such as shown in foreground running from the side to the floor are 2 in. angles. Alongside of the conveyor belt are wood sideboards supported by brackets built from 2 in. angles and 2 in. bars welded together as shown in Fig. 9. Feet of these vertical supporting members are formed by mitering one leg of the angle and bending it. When bent so that the angle support stands vertically, the mitered joint is welded and the support becomes a rigid vertical structure.

Fig. 6 (left)—New boiler house. The housing for stoker and boiler, the bases for blowers and motors, the stairways and railings are all of welded construction.

Fig. 7—The pulverized coal collector and blower system (center) is also of all welded construction.

Fig. 8 (right)—Hot air duct for coal pulverizer. This was built entirely from pieces of scrap iron, welded together as shown.

Fig. 9—Conveyor framework in sampler house. The wood sideboards are supported by brackets built from welded angles and bars.

The welding operations at the Golden Cycle Mill represent just a few of the many examples of how initiative, ingenuity and welding are conserving metal. Welding and the intelligent use of scrap materials not only assists the war effort but makes it possible to maintain and service equipment which otherwise would have to be shut down because of priority regulations.

* * *

Photos are reproduced through the courtesy of The Lincoln Electric Co., Cleveland.

★ TRAINING

Training Weldors in Wartime

By **A. S. McCOLL**
North American Aviation, Inc.

Betty King, who made record time in converting her talents from stenography to welding.

The instructor watches Miss King at work on a test weld.

FOR SEVERAL months prior to last December 7th, a limited number of industries were engaged in what was termed defense work. Some plants had converted their facilities, others had simply expanded. In general, however, management was endeavoring to produce for defense requirements with a minimum of dislocations and, in many cases, with little thought that it would be necessary to depart appreciably from established practice.

Defense thinking and defense planning had to be abandoned when a state of war supplanted that of armed neutrality. All industry had to be mobilized immediately to prepare an overwhelming offensive (which the enemy had attempted to prevent by his treacherous attack). The achievement of that objective meant both changes in method and changes of pace.

More Welding—More Weldors

Welding activity multiplied in volume. This was inevitable because war production is so largely steel production. It followed also that more welding demanded more welding operators. There was an immediate expansion of welding training facilities, both public and private, and thousands of men and boys rushed to learn this trade which promised quick employment at very high wages. But altogether too much of the new training program was laid out on pre-war lines.

In order to meet the unprecedented demand for weldors in our vital war industries, we should abandon all previous concepts of industrial training and adopt short cuts never before contemplated. Industry has accomplished miracles in the erection and tooling of new plants. The welding fraternity must accomplish another miracle to furnish the man and woman power to make these plants produce.

News releases have informed us of numerous cases where farms and prairies have become gigantic industrial plants in three or four months. As an illustration of what can be done and what must be done in the field of training, let us cite the case of Betty King, a stenographer who started from scratch and became a full-fledged aircraft weldor.

Trained in 13 Days

Betty had never seen an arc welding machine until she started her course in welding. After thirteen days of training she passed the Army test and started welding for North American Aircraft, Inc.—not on restricted specialty work but on general run of the mill welding on the production line. This, we believe, is a record. Bear in mind, please, that the aircraft welding qualification test is a severe one and that all welds made in production are subject to rigid inspection.

Betty King's experience appears to be contradictory to much of the current thinking on the subject of training welding operators. The question naturally arises as to how she could be qualified so soon. There are two answers. Betty is a bright young woman of 19 years, possessed of a mind that is eager, energetic and aggressive. The ability and the will to learn can govern the tempo of individual progress and, under war conditions, should be allowed to do so *regardless of the academic importance of schedule disciplines.* Secondly, all orthodox methods of instruction were discarded and a new "streamlined" training system was put into effect.

Principles and Practices

It is in the nature of this streamlined training system that it does not yield to description by formal outline. Following are some of the more important principles:

1. Classes are reduced in number so that the instructor can give a reasonable amount of time to each individual student. (This is very important.) One instructor should never have more than eight students under his guidance at any one period.
2. Right at the start, students are taught to set the controls of their welders to suit the job at hand. The beginner who gains early mastery over the equipment rapidly acquires control of confidence.
3. School work is devoted entirely to actual welding practice.
4. Instruction is given in various welding phases, not on particular parts or pieces.
5. Students start and finish on light weight material. It is easy to increase the amount of current and weld on heavy material, but it is very difficult to decrease current and weld

on thin stock if the student has been taught on heavier material.

Teachers Must Be Good Weldors

Selection of instructors has been sadly neglected. The instructor should be a first class weldor himself. Even this is not enough unless he also has the ability and the necessary patience to impart his knowledge to the student. Today, the general attitude toward our war aims of welding instructors should be carefully scrutinized. The window dressers and ornaments must be weeded out. Good instructors work harder than their students.

We grant that Betty King is an exception, and that the average student is not able to pass the Army test in thirteen days. However, we do have a number of students who have passed the qualification test in both arc and oxy-acetylene welding in 17 or 19 days after they started training.

Under war conditions, we want welding operators, not potential welding engineers. For this reason, no theory of welding, no books or pamphlets are supplied to the students during the instruction period. All that will come after they have passed their qualification tests. There is plenty of time for them to study after they are at work on the firing line. Our crying need now is immediate preparation for production.

A class of feminine weldors who averaged less than three weeks time to complete the training course.

Previously, the average welding student has required eight to ten weeks of instruction. Under this new method, two to three weeks does the job. The intensive streamlined course takes less of the instructors' time and uses it to better advantage. Elimination of all training frills conserves electrode material, which is becoming more and more difficult to obtain for training purposes.

On the whole, our record here certainly indicates that there can be considerable improvement in the usual methods of welding instruction.

* * *

Photos reproduced by courtesy of Wilson Welder & Metals Co., Inc., New York City.

★ ★ ★

Welding Foils Thieves

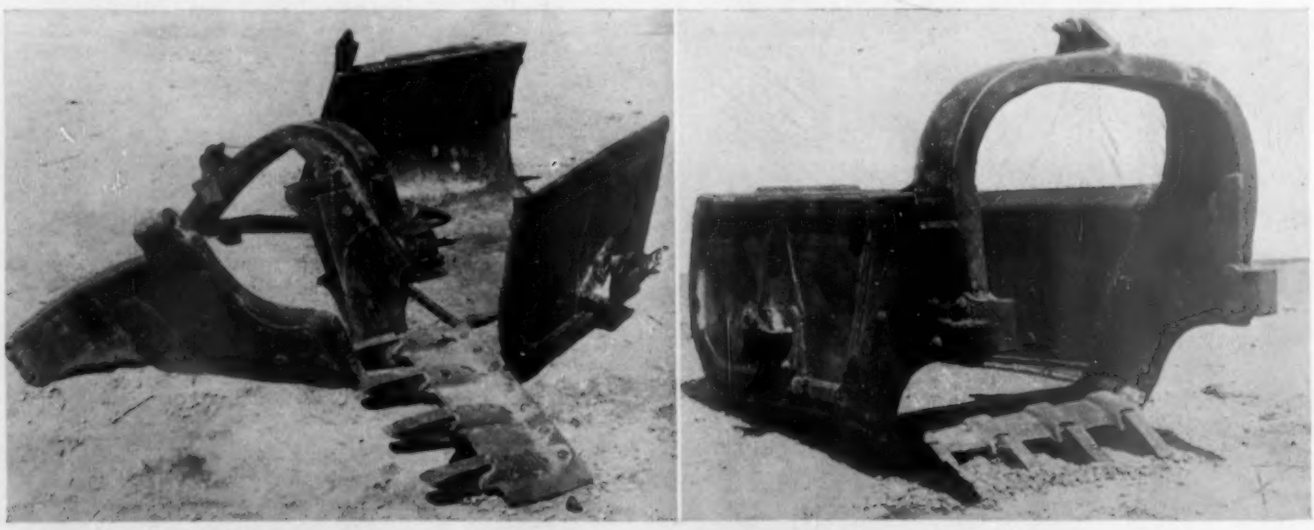
THANKS to the police and an arc welder, unpatriotic scrap thieves who stole a drag line bucket failed to interrupt the construction of a North Carolina military airport.

Armed with an acetylene torch, the thieves had cut the bucket into six pieces as shown in the left picture below. The pieces had been sold for scrap, but police authorities spotted them on a freight car enroute to the mills and shipped them back to the airport contractor.

The bucket was constructed from ¼ in. and ½ in. mild steel with a manganese wearing lip. It could be repaired by welding, promised Emmett C. Aldredge, job weldor from Dunn, N. C. He flame-cut for V-grooves and welded the fragments with $\frac{5}{16}$ and ¼ in. mild steel, general purpose, shielded-arc type electrodes.

The restored bucket is shown in the right hand picture. It looks and works like new. The welding repair job required ten hr. and cost $90. A new bucket of this size would have cost $365 and necessitated several weeks for delivery.

Photos by Hobart Brothers Co.



This bucket was stolen by thieves, who cut it into six pieces. These were found by the police, and the bucket was reconstructed by arc welding.

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Immediate Delivery of WELLS "Suregrip" HOLDERS

Ventilated Handle Stays Cool!

Proved by 16 Years of Nation-wide use

Now, with our production facilities greatly expanded, we can again make *immediate delivery* of fully insulated (illustrated) and non-insulated Wells Holders in large quantities. Order NOW through your local distributor or write direct.

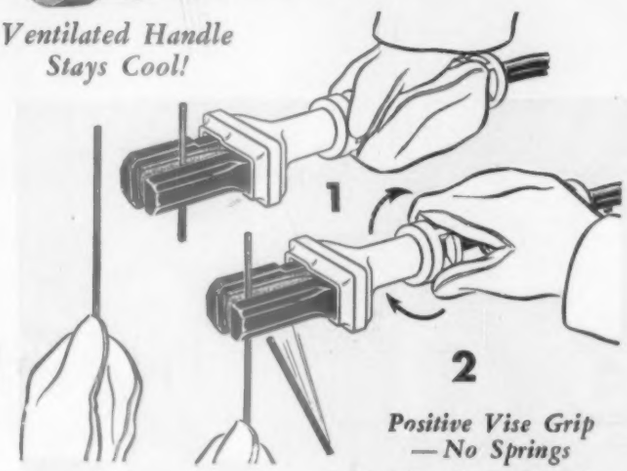
Perfect Balance Speeds Work

Welders who have "used 'em all" and new hands alike choose Wells "Suregrip" Holders. They are light, perfectly balanced, and the handle stays cool even on continuous heavy work.

The Wells positive vise-grip principle—introduced by us 16 years ago—enables "Suregrip" Holders to grip electrodes of all sizes in any desired position. Positive contact prevents overheating and burning of notches in the vise jaws—hence the life of Wells Holders is increased and replacement costs are cut.

Ventilated handle is constructed of shatter-proof, fabric-reinforced plastic. "Suregrip" Holders are able to stand up under severe service conditions. You will like them for their long-run economy—your operators will like them because they are practical, easy-operating tools.

Wire or write for prices and literature, or ask your distributor. Wells "Suregrip" Holders are available in 300 and 400 Amp models; fully insulated and non-insulated types.



Positive Vise Grip — No Springs

1. Using the new electrode as a pry, the vise is opened and the used wire dropped by a simple quarter turn of the handle; 2. a quarter turn back clamps the new electrode POSITIVELY and in any desired position. No springs or projections. Vise assembly is replaceable in a minute without removing cable from the handle.

Jaw Insulators Replaced on the Job in a Few Seconds

1. Break off old insulators. 2. slide new insulators into place on the jaws. When you have the insulators you have all you need. The insulators can't come loose in service. Newly developed plastic resists high heat and has no laminations to peel away under charring temperature.

Martin Wells

Manufacturer

5886 COMPTON AVE., LOS ANGELES, CALIFORNIA

Torch Tips to Order

New multiple-flame tips were made for oxy-acetylene welding torches when existing equipment proved inadequate for special war emergency production tasks.

By H. S. CARD
Director, Product Development,
Formed Steel Tube Institute

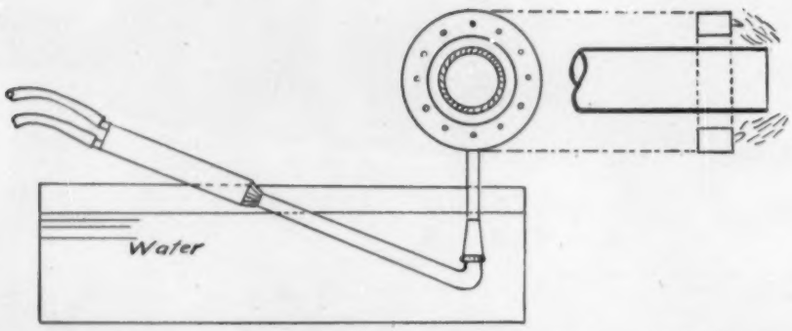


Fig. 1—Heating the end area of a welded steel tube for hot flanging by means of a 12-flame ring-type torch tip. This sketch was drawn only to give the general idea and is not to scale. Actually, the torch should be much larger to be in proportion to the ⅞ in. diam tube. The assembly is held in a fixture so that forward portion of torch is submerged in water for cooling.

DEVELOPMENT of special multiple-flame tips for oxy-acetylene welding torches quickened the speed of emergency production schedules in two instances in a midwestern plant. In both cases, a way was found to get production with the equipment and materials already on hand.

Heating for Hot Flanging

The first job was to heat the end area of a welded steel tube for hot flanging. The plant's equipment included an electric induction heater of suitable capacity, but only one, and it was needed to heat the opposite end of the tube for closing. To wait for delivery of a second induction heater would mean a cut of nearly 50% in the possible production rate.

It was decided to make use of the high-temperature oxy-acetylene flame. The plant's tool engineer designed a ring-type tip to fit a conventional welding torch, Fig. 1. The ring tip was machined from solid copper and drilled to provide 12 flames, directed slightly toward the center line of the ring. When the end of the steel tube is thrust through the ring, as shown at upper right in Fig. 1, the flames impinge on the entire periphery of the end area, and it is only a matter of seconds to get the temperature required for flanging. Since the time needed for flanging is very nearly the same as time taken for closing the opposite end of the tube, the production of complete tube parts is practically continuous.

Second Job: Silver Soldering

The second task was the silver soldering of a small outlet connection to a welded steel tube of larger diameter, Fig. 2. This was on a large order, placed on short notice and wanted in a very great hurry. There was no time to obtain special welding apparatus, no time to give a weldor the special training needed to make this weld in thin tubes so as to produce a smooth joint and not burn through the tube wall.

At first an attempt was made to fuse $\frac{1}{16}$ in. silver solder rings around the joint, using a small gas welding torch. Trouble immediately! Application of the high temperature flame caused the silver solder to run away before the tube wall was sufficiently heated.

The sketch, Fig. 2, shows how the difficulty was overcome by heating the tube inside. A button-type torch tip was made from a small piece of copper rod stock; this tip was joined to the mixing chamber of a small welding torch by means of a small, straight copper tube which permitted the flame to be inserted inside the larger steel tube. The torch tip was designed to furnish six flames, equally spaced on a circle somewhat larger than the diameter of the outlet connection.

The result of this arrangement is that the outlet connection acts as a chimney, drawing the flames inward and concentrating the heat on the joint area. The steel is heated first, and is at just the right temperature when the silver solder melts. Only a few seconds are needed to complete one of these joints, and the heat is so well regulated that "leakers" are practically nil.

These two procedures have proved to be so efficient that the word "makeshift" does not apply to them. They have made it possible to get into fast production — immediately, at reasonable cost, utilizing apparatus and materials already on hand.

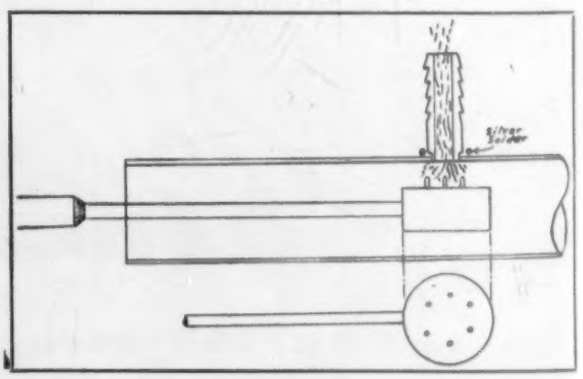
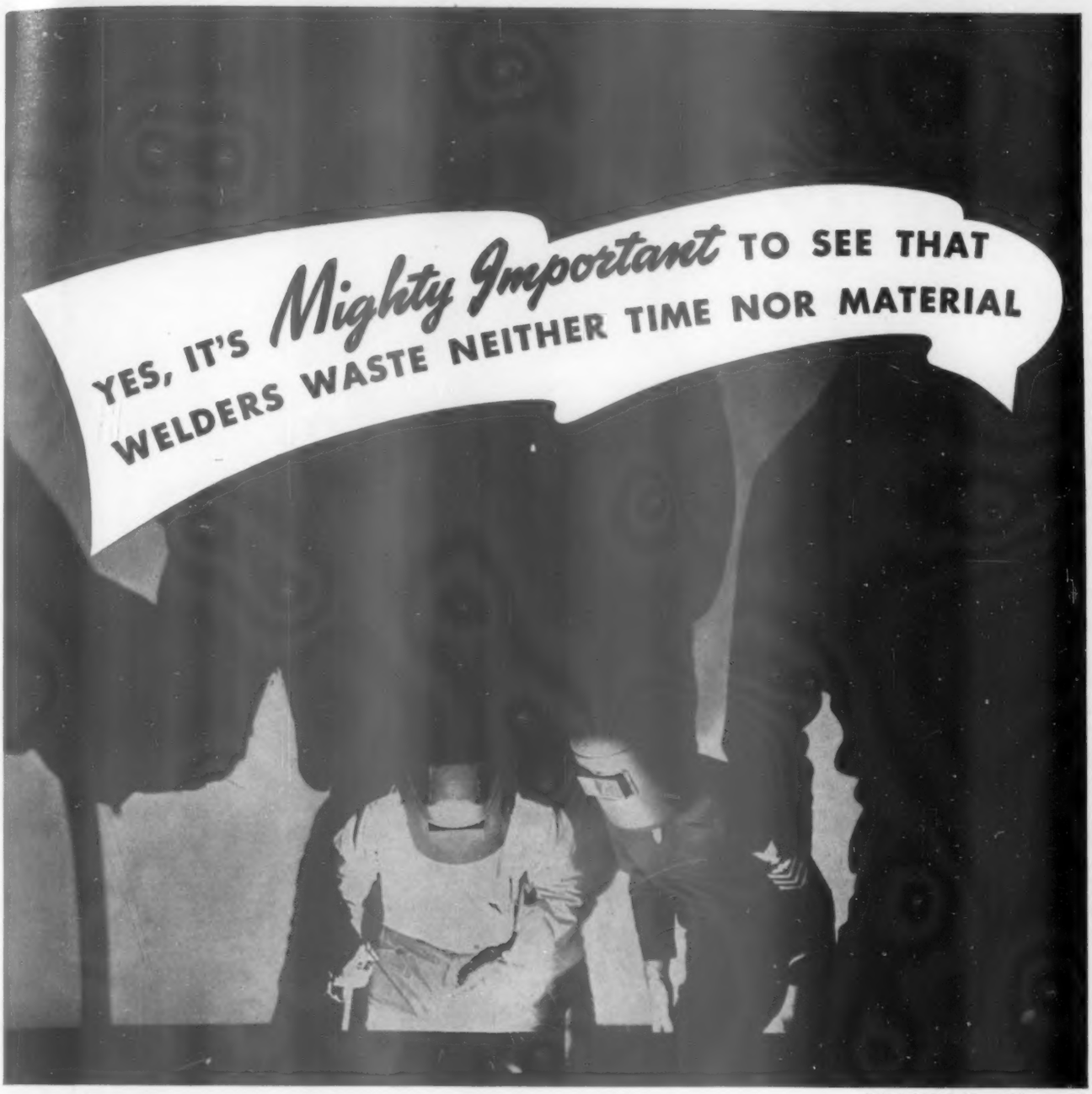


Fig. 2—Joining a small outlet connection to a welded steel tube of larger diameter. Torch tip is inserted inside the tube so that flames heat the area to be silver soldered from the under side.



Official U. S. Navy Photograph

★ When an experienced welder goes to work for the Navy, they don't just turn him loose on the job. Even the best of new men are trained with great care to work to Navy requirements—and are checked by experts.

Certainly, with the material and delivery situation as it is, it is good business to see that all industrial welding procedure is carefully checked—that electrodes of the proper size, leaning toward larger sizes, are used—that no electrodes are wasted—that no excess is deposited in the weld.

WELDING STAINLESS?
You will find a great deal of practical information on Stainless Steel and Stainless Steel Welding procedure in this 9x12 booklet. Get a copy from your local **PAGE** distributor.

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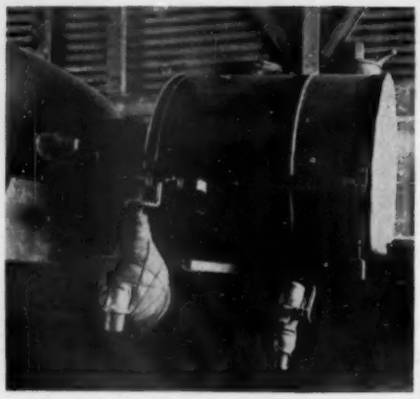
Brief Sketches of Welding Jobs

Dual Service Truck Tank

By C. C. LYNDE

To provide drinking water for the maintenance crew, and also to carry gasoline for washing valves, tools, hands, etc. after working in heavy oil, the weldor for an oil production company built a single truck tank which not only lessened the weight of equipment but also saved steel.

The job was begun by cutting one end from a standard tank. A flat sheet with diam 1 in. greater than the outside measurement of the tank was welded across to seal the tank completely. Then a band of tank stock was fitted to the end removed by the first cutting operation, and this section was welded to the outside of the oversize partition. Two tanks were thus formed, effectively separated, with one mounting for the two and with the saving of one head or end.



A welded partition on the inside of this truck tank makes it possible for the maintenance crew to draw either water or gasoline.

Outlets welded to the base permitted lines to be brought out to the side of the tank for drawing either water or gasoline. The water line was carried through a sand box, through which a bypass connection from the truck exhaust permitted the circulation of hot exhaust gases in winter in order to prevent freezing. The water valve was wrapped with burlap and covered by a discarded inner tube split lengthwise. This kept the water cool in summer.

» «

Crane for Gun Turrets

A gantry crane 12 ft high and made of arc welded steel tubing is being used to lift heavy gun turrets at a midwest war plant. The crane is 4 ft wide at the base and carries across its top a steel I-beam 9 ft long and 6 in. wide. It is mounted on 6 in. casters.

The framework was made of 1½ in. tubing (standard pipe), reinforced with ¾ in. steel webbing at the top. Four lengths of tubing, fastened at each end, were arc welded to a bottom

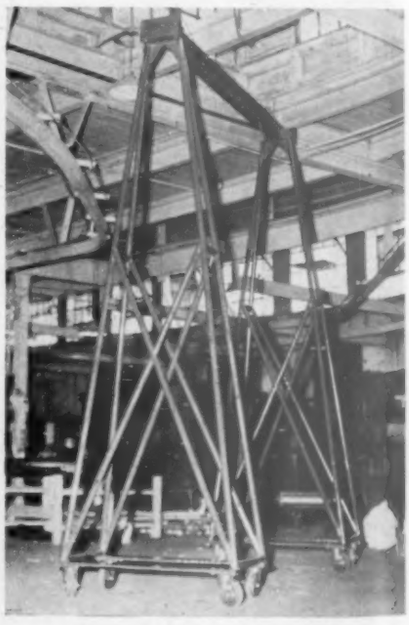


Photo by The Lincoln Electric Co.

Arc welded gantry crane 12 ft high, manufactured from steel tubing in order to lift heavy gun turrets.

HOW Bronze repair welding overcomes serious production problems

Anaconda 997 Low-Fuming Rod repairs this fractured press gear for punching artillery shell discs . . . has vital press back working inside two weeks . . . saves several months delay for replacement.

When this large gear on a press punching out shell discs cracked and groaned to a stop, it was apparent that a new gear could not be obtained for several months. But production was interrupted for only two weeks—thanks to repair welding with Anaconda 997 Low-Fuming Rod. The Hebeler Welding Company of Buffalo, New York, well-known specialists, did the job using 125 pounds of rod and 900 feet of air and gas. Chipping and welding required but 55 man hours.

This is but one of countless instances where Anaconda Welding Rods including Anaconda 997* and Tobin Bronze* have saved invaluable production time in war essential industries. Consider their use before scrapping any important machinery that seems beyond salvage. 4259A

*The trade-marks "Anaconda" and "Tobin Bronze" are registered in the U. S. Pat. Off.

ANACONDA *Anaconda Welding Rods*

THE AMERICAN BRASS COMPANY, General Offices: Waterbury, Connecticut

Subsidiary of Anaconda Copper Mining Co. • In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

framework of tubing, 4 ft long and 2 ft wide. As further support, four lengths of tubing were fastened from the base frame to the supports, these being attached at points 7 ft above the base. At these points, further bracing running parallel to the width of the lower frame was welded.

This crane was constructed by the Flori Pipe Co., St. Louis, at a total cost of $116.90. Labor cost was $34.50, steel cost $12.70 and tubing $34.40.

» «

Spool Silver Brazed

Big guns and their turrets are controlled by mechanisms of which an important part is the light-weight brass spool shown in the accompanying illustration.

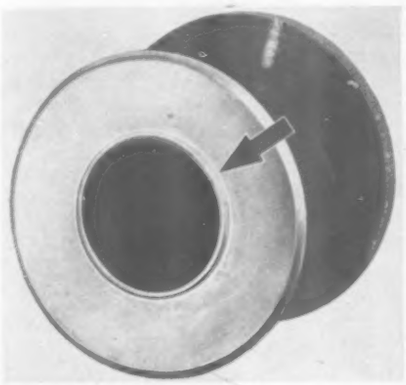


Photo by Handy & Harman

This light-weight brass spool is permanently joined to a brass tube by means of a low temperature silver brazing alloy. The joint, made easily and rapidly, is stronger than the brass itself.

The brass end-piece of this spool is fitted on a brass tube and joined permanently by a silver brazing alloy. The low brazing temperature of the alloy, 1175 F, makes it possible to eliminate distortion whereas the previous method, using a high temperature base metal brazing alloy, had considerably distorted the spool.

» «

Stop for Pipe Line

By M. T. PATE

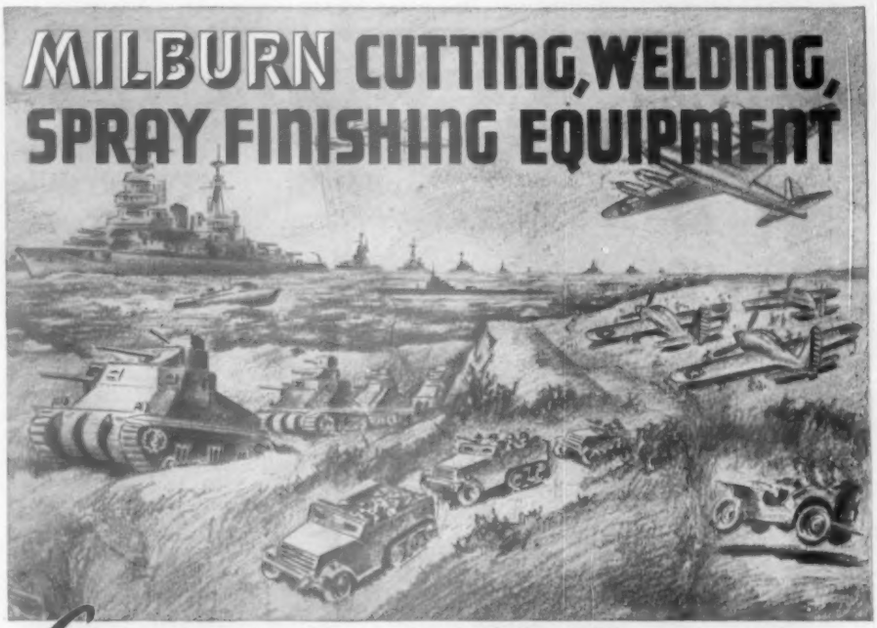
To enable welding to be done on a pipe line carrying petroleum products without danger of explosion, the weldor for a pipe line company devised the special stop shown in the picture below.

Two pairs of rubber washers used to drive the usual pipe line scraper through a line of given diam were run on a threaded bolt. The outer end of the bolt was welded to a washer of ½ in. steel plate, slightly smaller than pipe diam. A nut and large eye were placed outside the collar to afford means of gripping for tightening.

The other end of the stopper was also made of a steel disk of size to slip within the designated pipe. A nut was welded to the center of the disk. The fit of nut on thread was "handy" so as to encourage making up of the bolt in the nut when the device was placed within a pipe and the bolt tightened.

Pipe line stopper. Two pairs of rubber washers were placed with bevels alternating in opposite directions on a threaded bolt of the proper diam to fill the washer shank holes.

By tightening with a bar or wrench placed through the eye a seal can be effected against considerable pressure. This stop is more effective than the usual field method of ramming up an earth dike inside the pipe, and it does not require inflation equipment as do stops based on an expanding unit in which the force is applied by compressed air. After welding, the unit can be readily loosened and taken out through gate, tee or other connection down the line.



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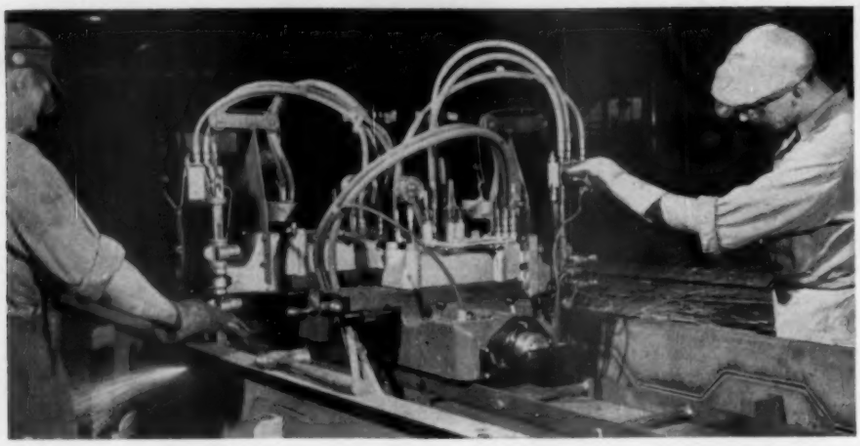

Photo by The Linde Air Products Co.

Traveling at a constant speed of 16 in. per minute, these oxy-acetylene cutting machines split two 35 ft channels simultaneously.

Flame Jigsaw

Two oxy-acetylene cutting machines are being employed to split 35 ft U-shaped channels in half in order to provide stiffeners for structural use.

The channels are loaded two at a time onto a special jig and clamped. Each cutting torch (see illustration) is mounted on a floating mechanism. The bottom of the machine rides along a templet, thus automatically producing the zig-zag line of cut, which was selected because it results in a saving of weight and steel while maintaining the strength necessary to the beam.

» «

Flame-Cut Gear Saves Shutdown

The rolling crew of a steel manufacturer were taking down a plate mill in order to grind the 60 ton backing-up rolls when they discovered one of the

Photo by Lukens Steel Co.

Flame-cut from steel plate 9⅛ in. thick, this replacement drive gear was made in five hr to replace a broken cast gear on a steel mill.

cast drive gears broken beyond repair. This gear measured 2 ft 11 in. OD, 9⅜ in. face. It could not be reproduced by casting without a long and costly delay.

The head roller put his problem up to the By-Products Steel Corp., division of Lukens Steel Co. A template was made to correspond to the gear's profile. In five hr a flame-cutting machine had duplicated the big 35-tooth gear from a steel plate 9⅜ in. thick. The only machining necessary was to grind the ID to fit the hub of the roll.

» «

Are you passing your copy of THE WELDING ENGINEER *on to your friends so that they, too, may become better informed on welding?*

Announcing 2 New Giant

C-F POSITIONERS

Capacities: 20,000 lbs.
20 inches away from table
8 inches off center

Capacities: 30,000 lbs.
24 inches away from table
18 inches off center

Write for new Positioner bulletin WP 22

These new giant C-F POSITIONERS (the one illustrated is the smaller) make the handling of really big work easy. With a few push buttons a welder can rotate his weldment or assembly in a complete 360° circle, can tilt it at any angle thru an arc of 135° off horizontal, can move it thru both planes at once to save valuable minutes and stop it at any point so that welds on all parts can be made down-hand—can have strong, smooth, flawless fillets. Pedestal mounted like all other C-F Positioners, on fixed or portable bases, these giants can be set at heights and in positions to give maximum convenience and floor clearance. They come with either constant or variable speed table rotations.

CULLEN-FRIESTEDT CO.,
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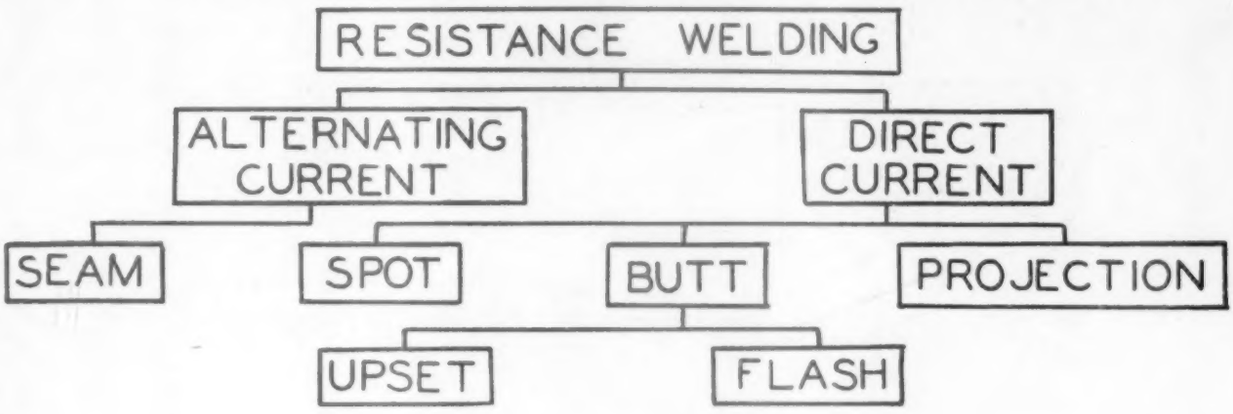
Resistance Welding Fundamentals



Definition

Resistance welding is a pressure welding process wherein the heat for welding is obtained by the resistance to flow of an electric current.

Principle

Resistance welding is accomplished when two or more pieces of metal are clamped between copper electrodes and an electric current is passed through them. Heat generated between the pieces of metal reduces the metal to a plastic state; then clamping pressure induces fusion. Pressure is required to make the resistance between the electrodes and the metal low as compared to the resistance between the pieces of metal; this condition must prevail when power is applied if burning of the working surfaces is to be avoided.

Fundamental Factors

The three fundamental factors which must be controlled in resistance welding are:

1. Current.
2. Time.
3. Pressure.

Heat Generation

It should be remembered that in any resistance welding process, the heat is generated within the metal and is not heat absorbed from an outside source. For this reason, the heat generated in resistance welding may be determined by the simple formula: Heat equals (Current)^2 times Resistance times Time or $H = I^2RT$.

Heat Generated

The energy represented by the expression I^2RT may be expressed in electrical units as watt-seconds or heat units as calories. If expressed in calories, a factor of 0.24 must be inserted in the formula as a watt-second is 0.24 calories. When resistance welding heat is to be discussed in calories, the formula becomes: Calories$=0.24\ I^2RT$.

Current Variables

Resistance welding current has three fundamental variables which must be controlled for consistent results. These are: (1) timing, (2) characteristic of the current wave during welding and (3) value of the current for a given weld.

Timing

Weld current timing in resistance welding may be accomplished by one of several methods. For example: (1) manually timed magnetic contactors, (2) mechanically timed magnetic contactors, (3) electrically timed magnetic contactors, (4) synchronous-motor-operated contactors, (5) electrically or mechanically timed ignitron tube contactors, (6) fully synchronous electronic timers.

Resistance Factors

The resistance in resistance welding is obtained from three sources: (1) The specific resistance of the material to be welded; this resistance is constant. The resistance from the other sources varies according to the pressure used. These resistances are: (2) resistance between the electrode and the work and (3) resistance between the pieces to be welded.

Pressure Methods

Pressure in resistance welding may be obtained: (1) mechanically, (2) pneumatically, (3) hydraulically, or (4) by a combination of one or more of these means.

Spot Welding Variables

Ten variables affect spot welding results:

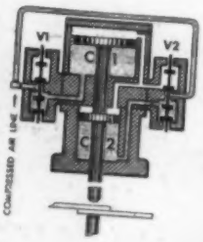
1. Human element.
2. Pressure.
3. Current.
4. Time.
5. Material.
6. Length of horns.
7. Distance between horns.
8. Power factor of welder and circuit.
9. Condition of electrodes and work.
10. Type and condition of work.

SOUNDER, MORE UNIFORM SPOT WELDS IN ALUMINUM ALLOYS!

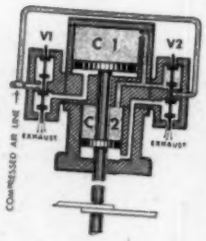
SCIAKY VARIABLE PRESSURE CYCLE

How it Operates

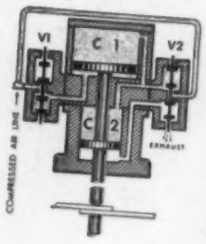
The variation of electrode pressure in the Sciaky Welding Process is effected by two air cylinders of different cross sectional areas (C-1 and C-2), mounted on upper arm of machine. Dual electro-valves (V-1 and V-2) control their action. Duration of each stage in the cycle is governed by precision electric controls.



1. REST POSITION. Electrode retracted. Both electro-valves are de-energized which permits air pressure to be exerted on the under side of pistons in both cylinders, thus lifting the electrodes.

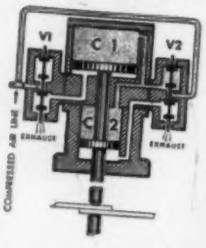


2. PRE-COMPRESSION. Both electro-valves are energized, admitting air pressure to the top of the pistons in both cylinders, thereby forcing the electrode downward with maximum pressure.

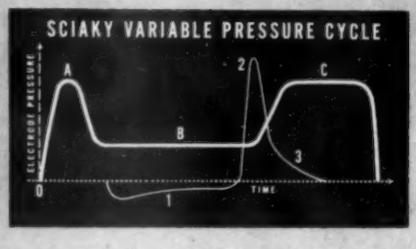


3. WELDING PRESSURE. Left electro-valve is de-energized. Pressure is maintained on top of piston in lower (smaller) cylinder, while air is admitted to under side of piston in upper cylinder. This neutralizes the downward pressure in the upper cylinder, and reduces the effective electrode pressure to about one-third of maximum.

4. RECOMPRESSION. Both electro-valves are again energized. The neutralizing (upward air pressure) on under side of piston in upper cylinder is exhausted almost instantaneously, restoring the electrode pressure to maximum —the same value as during pre-compression.



SCIAKY* WELDING PROCESS "FORGES" THE METAL AFTER THE WELD....



Precompression (initial contact pressure) is indicated at A. Welding (reduced) pressure at B, and Recompression (forging pressure) at C. Electrical current is indicated by light line. During storage of energy period (1) the metal is preheated. The surge of current to maximum (2) effects the weld, and decays, (3) following the exponential curve.

Type PMCO2S-16 Sciaky Stored Energy Electric Resistance Spot Welder

In spot welding any metal, the inner surfaces of the pieces being joined are converted from a solid to a molten state at the point of passage of the welding current. This conversion in aluminum and its alloys requires a very high temperature which results in expansion of the metal in the molten zone.

The subsequent cooling of this zone is extremely rapid because of the high thermal conductivity of aluminum, and also because the artificial cooling of the copper electrodes with which the aluminum at high temperatures would otherwise tend to alloy. This rapid cooling causes sudden contraction of the weld nugget and the consequent cracks and internal stresses tend to weaken the weld.

The Sciaky Process embodies exclusive features to compensate for these undesirable conditions. In addition to pre-heating, which offsets the high thermal conductivity of aluminum and in consequence slows down the cooling process, Sciaky provides the added protection of a "forging" pressure to offset the metal shrinkage. Thus the Variable Pressure Cycle combines with the Stored Energy Principle and the exclusive pre-heating feature to insure welds of sound metallurgical quality.

As a result, the Sciaky Welding Process is preferred by practically all major manufacturers of air craft.

SCIAKY BROS.

Manufacturers of a Complete Line of D-C and A-C Electric Resistance Welding Machines

4915 West 67th Street, Chicago, Illinois

*Pronounced See-ack-ee

SCIAKY

PROCESS ELECTRIC RESISTANCE WELDING
STORED ENERGY • VARIABLE PRESSURE

New Product Developments

Giant Electrode

★ A "man-size" coated electrode, ½ in. diam, 28 in. long, is the new **Armorac Type B,** said to be the largest welding rod now being made and designed expressly for welding tanks. This electrode, manufacturer states, will increase weld metal deposition to a rate four times over estimates contemplated prior to its development. The new large size owes its practicability to the type of coating, which permits use of the rod down to a small stub without cracking.

Armorac Type B electrodes are also made in 5/32, 3/16, 7/32, ¼, 5/16, 3/8 and ⅛ in. diam. Sizes of 5/16 in. and larger operate on both A-C and D-C current.

Further information (available solely to holders of ordnance contracts), may be obtained from **Alloy Rods Co.,** York, Pa.

» «

Hydraulic Drill Vise

★ Though intended primarily for drill work, the new Studebaker **"Drilvise"** is suitable for many other kinds of jobs as well. It is hydraulically operated.

Work, placed between open vice jaws, is gripped by depressing center foot pedal. Right pedal moves the jaw a maximum of 1/16 in. for each downward stroke of the foot, exerting up to the maximum pressure of 10,000 psi. The left pedal, depressed with one downward movement of the foot, releases work held between the jaws.

Further details may be obtained from the **Studebaker Machine Co.,** 9 S. Clinton St., Chicago.

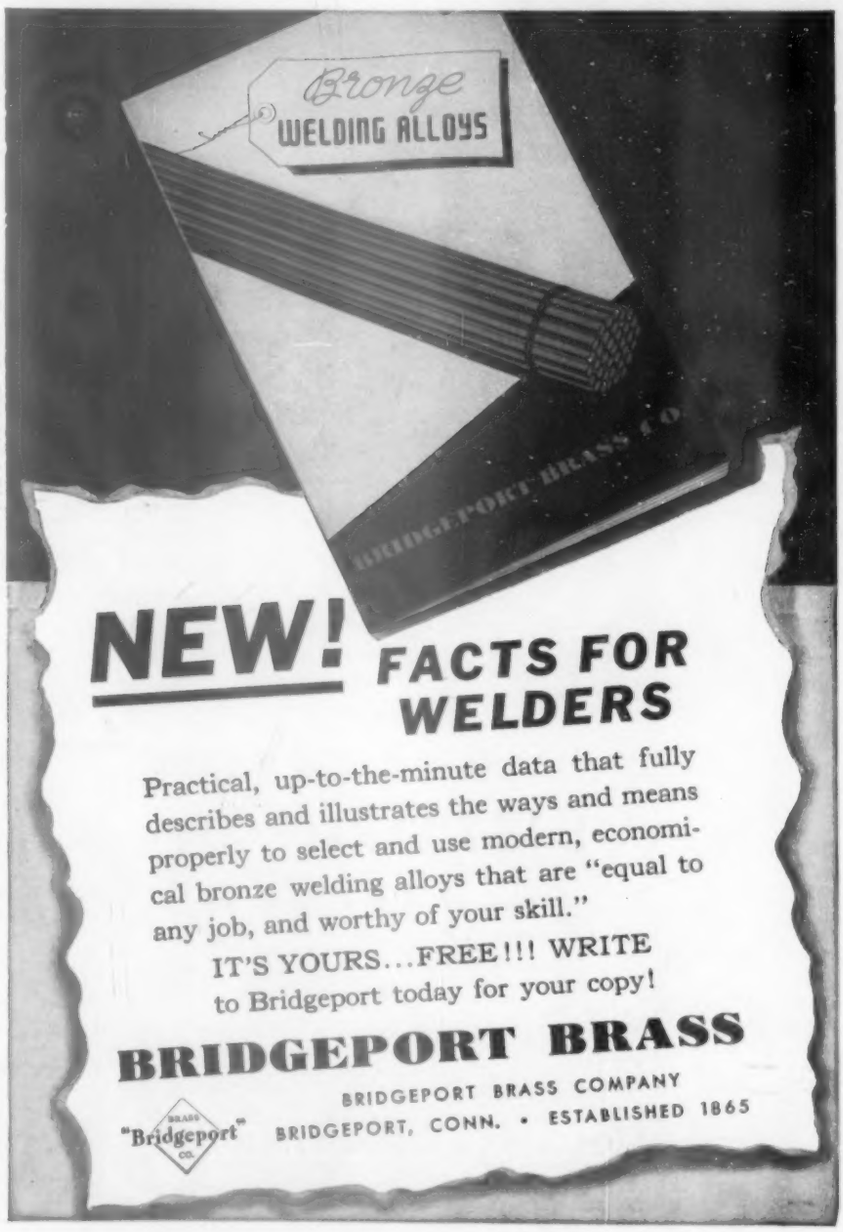
The "Drilvise" is foot controlled, giving operator the use of both hands for the machine on which vise is mounted.

G-E crater filler, DL-8020711G1, for use with Type WD "Strikeasy" arc welder.

Crater Filler

★ A new **crater filler** has been announced for use with the **General Electric** "Strikeasy" single operator arc welder. This device is designed to provide very close auxiliary control of heat and to permit tapering off of the welding current at the end of a bead in order to fill the crater which would otherwise be left. It is not intended to replace the control unit on the welder but is to be used only to increase or decrease the heat setting to accommodate abnormal conditions at the beginning or end of a weld (or during a weld, if necessary). Normal welding heats, stresses manufacturer, should be adjusted in the usual way.

The crater filler is, essentially, a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WELDING ALLOYS
BRIDGEPORT BRASS CO.
NEW! FACTS FOR WELDERS
Practical, up-to-the-minute data that fully describes and illustrates the ways and means properly to select and use modern, economical bronze welding alloys that are "equal to any job, and worthy of your skill."
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combination of a foot-operated rheostat for reducing the current and a field forcing switch for providing a "hot" start or an increase in welding current when required. Both increase and decrease of current may take effect instantaneously. At the time of breaking of the arc, however, the crater filler permits either a rapid or a slow decrease in current down to the point where arc is extinguished. This permits the operator to suit the rate of current "fading" to the conditions of the particular weld and assists him in mastering the technique of finishing a bead without a crater.

The crater filler is also helpful when working with thin material such as aircraft tubing where normal welding heats are low, as it takes care of "emergency" conditions for which normal welding heats may be insufficient.

» «

Radial Spot Welder

★ A radial-type **gun spot welder**, P-1-R, is now being offered by **Sciaky Bros.**, 4915 W. 67th St., Chicago, in both stationary and buggy-mounted units. It is equipped with a special Sciaky welding timer and operates on single phase A-C, 220 or 440 volts. Hydraulic pressure is supplied by a hydro- pneumatic booster, which can feed a gun able to supply a maximum electrode pressure of 1,800 lb with 90 psi of air supply.

Fixed or crowded jigs can be easily reached with the portable buggy-mounted welding gun (illustrated). The

New Sciaky radial spot welder, P-1-R, which is available in either stationary or buggy-mounted (illustrated) units.

maximum area reached by the stationary unit is represented by a circle of 21 ft. diam.

Secondary cables are thin, flexible and short; the reduction in the usual size of secondary cables is made possible because of the use of fixed heavy copper bars (water-cooled) in the length of the secondary circuit.

In steady production conditions, this welder is capable of welding: corrosion-resisting steel, pickled steel, zinc-coated steel and Monel metal in thicknesses of from 0.016 in. plus 0.016 in. up to 0.064 in. plus 0.064 in. It will also weld two unequal thicknesses up to a total welded thickness of 0.500 in., provided that one of the two thicknesses does not exceed 0.040 in.

In welding pickled mild steel or standard steel, a speed of 180 satisfactory spot welds per min can be attained on thicknesses up to 0.032 plus 0.032 in. Speed decreases as the sheet thickness increases.

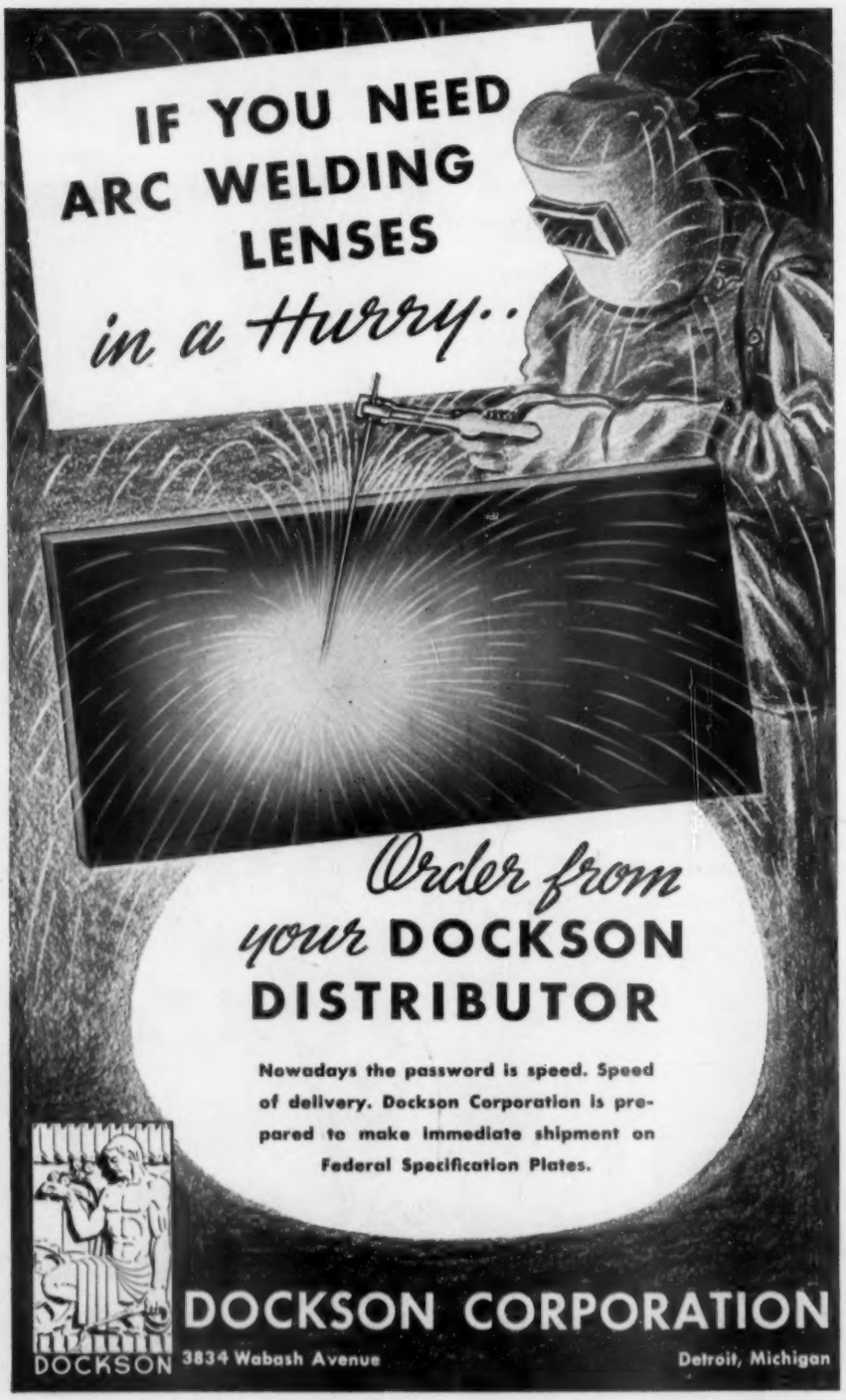
» «

Cable Coupler

★ The Burndy "Hyclasp" is a separable coupler for wires and cables, said to be particularly useful for welding cables as well as for quick disconnecting of equipment that must be periodically tested. Type YK, illustrated, can

New separable cable coupler (also known as a jack knife connector) for quick making or breaking of circuit.

be supplied for Navy, standard, flexible and extra flexible cable in sizes from No. 4 Stranded to 1,000,000 cir mil. It is connected by means of the "Hypress," a hydraulic tool. **Burndy Engineering Co., Inc.**, 459 East 133rd St., New York City.



News of the Industry

Those in our Nation's Armed Forces may continue to read The Welding Engineer at the special reduced price of $1.50 per year for the duration.

» «

Radiographic Laboratory Opened at Illinois Tech

★ A laboratory for the X-ray and gamma-ray examination of metals for America's war effort has been completed at the Illinois Institute of Technology, Chicago, to train experts in the radiographic inspection of metals and metallurgical welding and casting. Approximately $4,000 is invested in the equipment, which includes a 200 kw X-ray tube and 100 milligrams of radium.

A class of 25 men will be in constant training in X-ray and radium testing under the direction of Dr. Otto Zmeskal, designer of the new laboratory. A special 10-week course in this subject is offered for students who have had either college-level physics or experience in conventional X-ray technique. Graduates will become inspectors for both private war industry and for the Army and Navy ordnance districts.

The class and laboratory work includes training in inspection of all three main groups of metals used in war production; namely, brasses and bronzes, the ferrous metals of armor and battleships and the aluminum and magnesium of aircraft.

» «

Lincoln Electric Co. Donates Scrap Rubber

★ Between 2,500 and 3,000 lb of scrap rubber was donated to the U. S. Government by The Lincoln Electric Co., Cleveland, during the recent scrap rubber drive. The rubber consisted of scrap mule tires, ends of welding cables, rubber gaskets and discarded V-belts —all of which had been accumulating around the plant for about three months prior to the drive.

Personals

Two department managers have been elevated to vice-presidency positions with the **Whiting Corp.**, Harvey, Ill. They are: **H. W. Anderson**, vice-president of the Aviation Div., and **M. J. Rice**, vice-president of the Quickwork-Whiting Div.

» «

G. P. Longabaugh has been appointed section manufacturing engineer on the headquarters subcontracting staff of **Westinghouse Electric & Mfg. Co.** In this assignment, he will assist the many outside manufacturers who receive subcontracts for war work from Westinghouse.

» «

William L. Davis, formerly superintendent of the Texas warehouse of the Tennessee Coal, Iron & R. R. Co., has joined the **Scully Steel Products Co.**, United States Steel Corp. subsidiary, as manager of operations. **James R. Beers**, sales representative in the Milwaukee sales office for Scully, has been appointed manager of this office to succeed **John E. Hayes**, who retired after 26 years with Scully.

» «

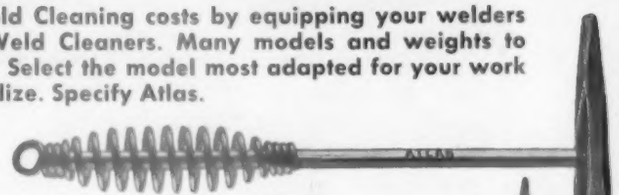
Paul W. Norris, J. T. Hively, George L. Avery and **Walter H. Hackett** have been promoted to new positions with the **Denison Engineering Co.**, Columbus, O.

Mr. Norris, who was formerly manager of purchasing and production planning, has been made manager of marketing. Mr. Hively, formerly head of the personnel and public relations department, has been made manager of purchases.

Mr. Avery, formerly office manager, now assumes the duties of manager of priorities and production requirements. Mr. Hacket, formerly assistant manager of personnel, has been made manager of personnel and public relations.

★ATLAS★

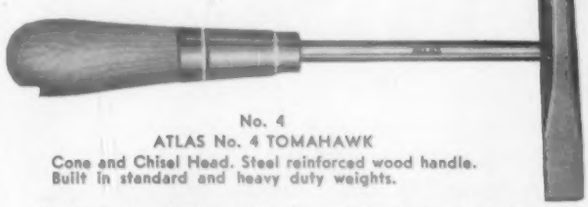
Cut your Weld Cleaning costs by equipping your welders with Atlas Weld Cleaners. Many models and weights to choose from. Select the model most adapted for your work and standardize. Specify Atlas.



No. 1
ATLAS No. 1 TOMAHAWK
Double Chisel Head. Flex-O type Handle—Built in standard and heavy weights.

No. 2
ATLAS No. 2 TOMAHAWK
Cone and Chisel Head. Flex-O type handle. Built in Standard and Heavy duty weights.

No. 3
ATLAS No. 3 TOMAHAWK
Double Chisel Head. Steel reinforced wood handle. Built in standard and heavy duty weights.



No. 4
ATLAS No. 4 TOMAHAWK
Cone and Chisel Head. Steel reinforced wood handle. Built in standard and heavy duty weights.

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Contact your Dealer—if he doesn't handle the Atlas line, write direct for the tools you are interested in.

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Current Reviews

Bronze Electrode Bulletin

"Ampco-Trode 10" is the title of a 6-page, letterhead-size bulletin describing in detail a new all-purpose, coated, aluminum bronze electrode which is now available in diam from 5/32 to ½ in. The bulletin gives the physical properties and chemical composition of this electrode and also describes procedures for various types of metallic arc welding, including cast iron, cast manganese bronze, Muntz metal and brass. A number of diagrams illustrate methods of welding, deep groove preparation, building up metal on vertical surfaces, weaving sequence and method of depositing beads. **Ampco Metal, Inc.,** 1745 S. 38th St., Milwaukee.

» «

Positioner Booklet

Welding positioners, their function, investment value and features, are the subject of **Bulletin WP-22,** "C-F Positioners," just issued by **Cullen-Friestedt Co.,** 1300 S. Kilbourn Ave., Chicago. This is a 16-page letterhead-size bulletin, profusely illustrated by photographic reproductions of positioners at work in many industries. Both portable and fixed types of positioners are covered.

Electronic Control Booklet

A new 38-page illustrated booklet, **B-3102,** giving a simplified explanation of electronic control for resistance welding, may be obtained from any district office of the **Westinghouse Electric & Mfg. Co.** This booklet illustrates and describes the various types of electronic controls, and explains where and how each is applied. Included in the same publication are three pages of application data on the choice and application of a single phase A-C resistance welding control, an 8-page bulletin on fundamental electronic circuits, and a discussion of the cathode ray oscilloscope and its application to welding timers.

» «

Clamp Catalog

Adjustable Clamp Co., 417 N. Ashland Ave., Chicago, announces publication of its new **Catalog No. 16.** This is a 36-page book, 6 by 9 inches, entirely devoted to the "Jorgensen," "Pony," and "Mark" lines of clamps and clamp fixtures. Extensive information on the "Jorgensen" shielded weldors' clamp is given on pages 22 and 23. The catalog is printed in two colors throughout.

» «

Arc Welder Leaflet

Much information on the Larkin arc welder line is given in the single-page, letterhead-size leaflet just published by **Larkin Lectro Products Corp.,** 220 Taaffe Place, Brooklyn. These welders feature an instant, easily maintained arc in all positions. They are available for practically all welding jobs from heavy duty structural work to light sheet metal welding.

» «

Hard-Facing Bulletin

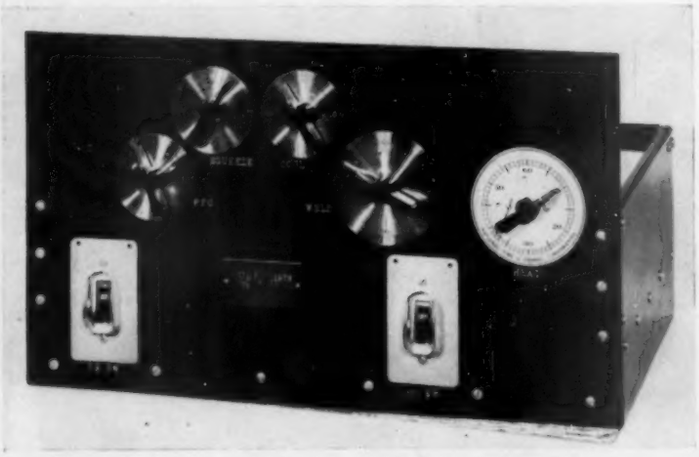
Uses of Amsco Dieweld, a tool steel welding rod for salvaging dies, tools, etc., are described in a 4-page letterhead-size folder, **Bulletin No. 742W,** just published by the **American Manganese Steel Div.** of the American Brake Shoe & Foundry Co., 389 East 14th St., Chicago Heights, Ill. Dieweld is an alloy containing chromium, molybdenum, silicon and carbon; it provides a weld metal which is air-hardening as deposited but which may be softened through proper heat treatment for machining and later rehardened within a desirable range.

» «

Booklet on Metering

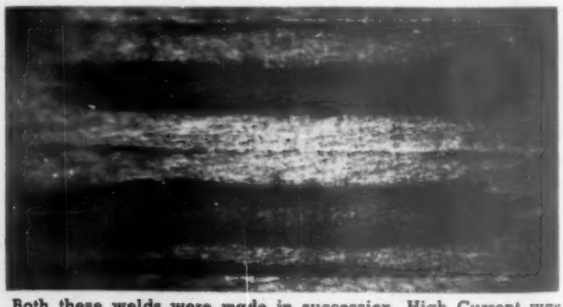
An 18-page illustrated booklet on kva demand metering, **B-3135,** may be secured from Department 7-N-20, **Westinghouse Electric & Mfg. Co.,** East Pittsburgh, Pa. This booklet outlines the most recent developments and explains how kva demand metering can be used with existing facilities.

For ALCLAD Spot Welding — USE **TRI-TROL** — The Complete WELD-CONTROL and Sequence Panel, with Automatic **HY-LO** Current Flow



Passes very high Weld Current for ½ cycle, followed by variable Tempered Heat for the balance of the Weld Interval.
Prevents Cracks
Makes Uniform Welds
Prevents Indentation
Makes a Ductile Joint.
Penetration is Regulated by the Dials.

Industry knows of the Heat Treatment of Steel, and how important the Cooling Process is. National just applied this idea to Aluminum Welding, and brought this treacherous metal under the Control of Tri-Trol dials. At the right, you observe how Tempered Heat is used to alter the extent of penetration, in 2 pieces of .016" Alclad sheet.



Both these welds were made in succession. High Current was not changed. Weld time was 2 cycles. Top weld with 40% Penetration, used Tempered Heat 40% off High Heat. Lower weld, with 50% Penetration, used 25% reduction.

NATIONAL TIME & SIGNAL CORPORATION
600 E. MILWAUKEE AVENUE DETROIT, MICHIGAN

Electrode Conservation

To help along the "fight waste" campaign, Airco has just issued a new 14-page, letterhead-size bulletin which includes a series of **six shop posters** designed to aid arc welding operators to do more useful work with every electrode. Posters are perforated and can be readily detached and tacked on shop bulletin boards. Each poster illustrates a common wasteful practice and then shows the corresponding good practice. Copies of this booklet, "Make 3 do the work of 4," may be obtained without obligation by addressing the **Air Reduction Sales Co.**, 60 East 42nd St., New York City, or the nearest Airco district office.

» «

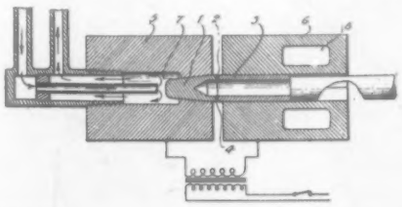
Lincoln Booklet

The Lincoln Electric Co., Cleveland, has just published a 12-page booklet, **"Intelligent Selfishness and Manufacturing,"** written by President James F. Lincoln to explain the arrangement which his company has had over the last 28 years with regard to "incentive" payments to employees. This policy has gone through several booms and slumps and has covered a long enough period, thinks President Lincoln, to demonstrate what might be expected from its pursuance generally in industry. At Lincoln Electric, considered as a test case, the results have been wholly satisfactory from the viewpoint of both employer and employee.

Recent Patents

Spot Welding Electrode

2,293,523. **Harold B. Warren**, Cincinnati, O., assigned to **General Motors Corp.**, Detroit. Filed July 14, 1939. Issued Aug. 18, 1942. This patent pertains to a



method of making a spot welding electrode. Under this method, a block of semi-precious metal comprising a copper alloy is stamped to form a tapered welding tip recessed at one end and having the end of the wall around the recess chamfered. Then a piece of less precious copper tubing having a chamfered end is welded to the chamfered end of the tip, tip being cooled by water circulating in contact with it.

» «

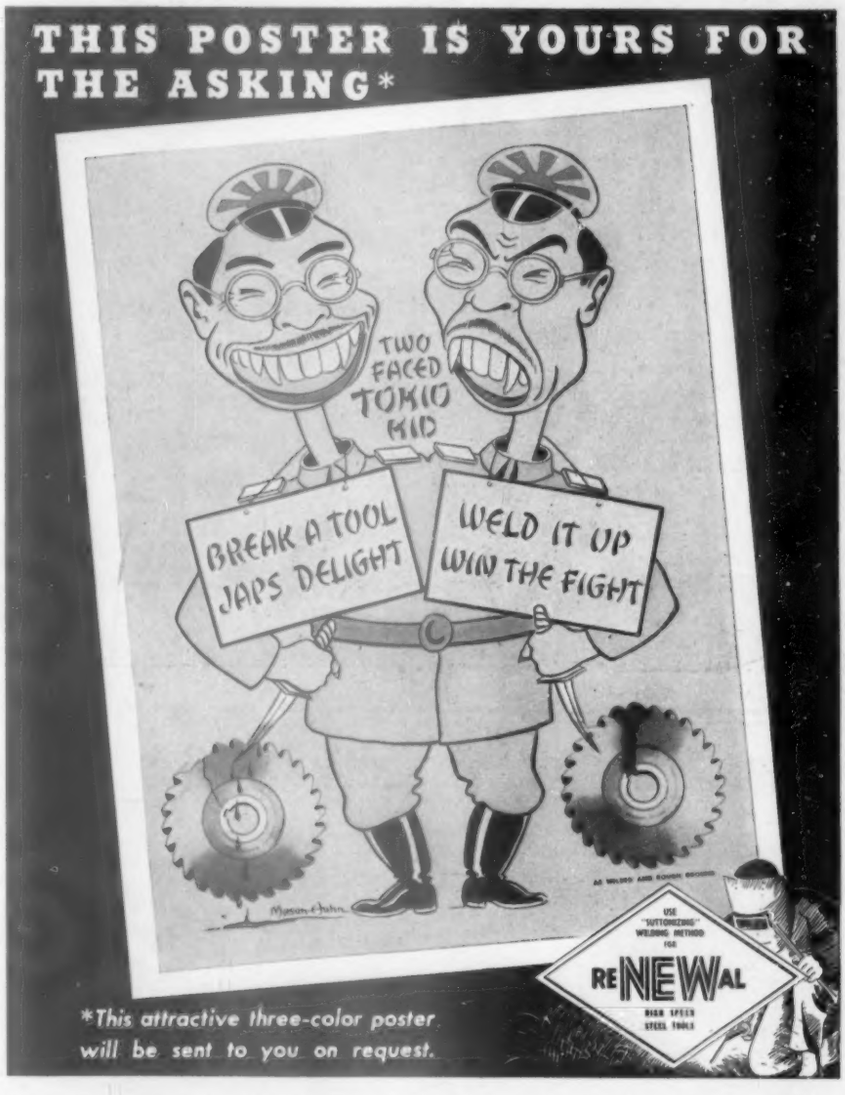
Multiple Spot Welder

2,293,535. **Frank A. Doll** and **Charles Kurz**, Detroit, assigned to **General Motors Corp.**, Detroit. Filed March 19, 1941. Assigned Aug. 18, 1942. This patent pertains to a machine for welding assemblies requiring a large number of spot welds. The combination includes a support, a plurality of welding electrodes carried on the support, fluid operated devices for bringing the electrodes against the work, back-up electrodes carried by the support, means for expanding the support to straddle the works and means for pulling the back-up electrodes down against one side of the work to pinch the work when fluid is turned into the fluid devices to bring the other electrodes against the work. Also included are a distributor having a plurality of secondary leads and a rotor for distributing current successively to them. Several electrodes are connected to each secondary lead, each group of electrodes simultaneously contacting the work and including only part of the electrodes connected with each secondary lead.

» «

Spot Welding Gun

2,293,511. **Joseph R. Lex**, Detroit, assigned to **General Motors Corp.**, Detroit. Filed Oct. 28, 1935. Issued Aug. 18, 1942. A device for welding bars. It


THIS POSTER IS YOURS FOR THE ASKING*
TWO FACED TOKIO KID
BREAK A TOOL JAPS DELIGHT
WELD IT UP WIN THE FIGHT
RENEWAL
*This attractive three-color poster will be sent to you on request.

The above poster refers to tools reclaimed by the "Suttonizing" welding process. This new method can be applied only in our own plant. Tools sent to us can be repaired and returned promptly without *post heat treatment* in the majority of cases. Wire, phone or write us today for poster and further information.

EUREKA electrodes are sold for your use on oil, water and air hardening steels as well as for hot forming and cold drawing dies.

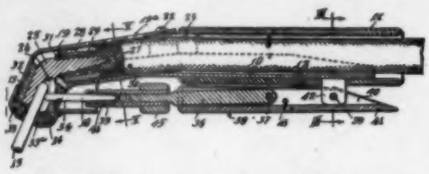
WELDING EQUIPMENT & SUPPLY CO.
221 Leib Street • Detroit, Mich.

includes two bar conductors, closely adjacent but insulated from each other; a bridging tool comprising a frame in which is located a handle forming a fluid cylinder; a pair of contacts, one moving relatively to the other, for establishing a circuit through the conductors, the work and the tool; and a piston reciprocating in the cylinder and having connections with the movable contact. Piston moves contact to establish the circuit when fluid is turned into the cylinder.

» «

Electrode Holder

2,293,157. **Jesse F. McGinnis,** Los Angeles, assigned to **M. L. B. Mfg. Co.,**



Hollywood. Filed Sept. 29, 1941. Issued Aug. 18, 1942. An electrode holder comprising handle and electrode socket, means for locking an electrode to socket, means for supporting socket from handle and means for effecting electrical connection between the socket and a current-supply cable. The latter means includes a pin member integral with the socket and adapted to extend into the end of a stranded cable conductor and a sleeve adapted to surround the pin and the separated strands of the cable, compressing the strands against the pin.

» «

Electrode Holder

2,293,159. **Ford S. Miller,** Lancaster, N. H., assigned to **M. L. B. Mfg. Co.,** Hollywood, Calif. Filed Sept. 29, 1941. Issued Aug. 18, 1942. A device comprising a hollow handle adapted to receive an electric cable, a frame extending forwardly from handle and at least partially enclosing cable, an electrode socket within the frame, frame having an opening in its extreme forward end for reception of electrode, an electrical insulating means for supporting socket and insulating it from frame, and a means for locking an electrode in socket.

» «

Submerged Melt Welding

2,293,163. **Edward D. Morris,** Chicago, assigned to **The Linde Air Products Co.** Filed June 20, 1940. Issued Aug. 18, 1942. A method of plug welding which comprises deposition of a granular fusible mineral welding material upon a limited area of the work and insertion of the end of a fusible welding electrode into this material. Electric current is passed from the end of the electrode through the granular material to the work. During the entire welding operation, there is maintained, above the welding puddle and surrounding the electrode, a horizontally stationary column of welding material of sufficient height to substantially counteract rise of molten material along the electrode and overheating of successive portions of electrode before they reach the welding region.

» «

Multiple Spot Welder

2,293,169. **Henry Thomas Platz,** Detroit, assigned to **Briggs Mfg. Co.,** Detroit. Filed March 31, 1941. Issued Aug. 18, 1942. This patent pertains to a track and a plurality of groups of electrodes which are supported above the track in spaced relation to each other in the direction of length of the track. A plurality of work supporting carriages are movable along the track by a step by step movement which successively positions the work in registration with the groups of electrodes. A means is provided for lifting the carriages off the track (during the intervals of rest of the carriages) in order to position the work in operative relation to the electrodes. Means for stopping the carriages in registration with the lifting means and for retarding their movement prior to stopping are also provided.

LARKIN arc welders

on the job
24 HOURS DAILY

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LARKIN LOCKWELD ELECTRODES for LARKIN WELDERS

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Model # 400C (40-400 amperes) Most popular size these days

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The Hood of the Improved "Round File" Gas Lighter is so designed as to form a "pocket" for the gas—an exclusive feature—which assures IMMEDIATE ignition. Get acquainted with the many other superior, exclusive features of Improved "Round File."

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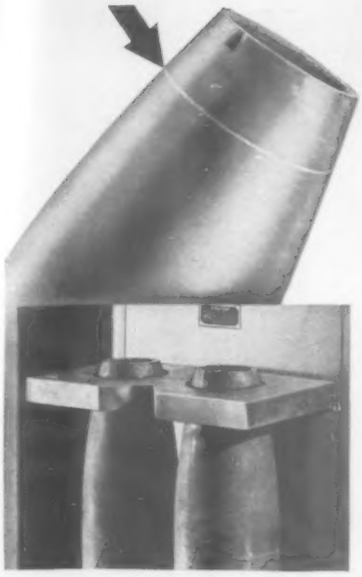

FAST PRODUCTION OF LEAK-TIGHT JOINTS WITH EASY-FLO

Here's another case where **strong, sound joints*** brazed with EASY-FLO plus a procedure designed to facilitate handling and heating have speeded up production.

THE JOB—Making leak-tight joints between steel adapters and steel bodies of 75, 81, 105 and 155 mm. shells.

PROCEDURE—After fluxing, a ring of EASY-FLO is preplaced in a groove in the adapters which are then assembled in the bodies. Next the assemblies are placed as shown in the work coils of an induction heating unit. A switch is thrown and in a matter of seconds the joints are made. The result is a steady stream of brazed shells.

WE'RE READY TO HELP YOU SPEED UP YOUR BRAZING
If you can use increased production, or better joints, on any ferrous, nonferrous or dissimilar metal joining job, we're ready to send a Field Engineer to show what EASY-FLO can do and to help you work out the most effective procedure for the job.

FOR FULL DETAILS ABOUT EASY-FLO
WRITE FOR BULLETIN No. 12

***REASONS WHY EASY-FLO MAKES LEAK-TIGHT JOINTS IN QUICK TIME**

Exceptionally free-flowing, EASY-FLO penetrates instantly to all parts of a joint and into the joined metal surfaces, actually alloying with them. Add to this fast penetration, the low flow point of EASY-FLO—1175° F.—and you have the answer to EASY-FLO brazing SPEED plus RELIABILITY. Complete details in Bulletin No. 12.

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Doubly-Deoxidized Welding Alloys:

PENN BRONZE

TITAN BRONZE

TITAN MANGANESE BRONZE

Titan's Quality Control

ASSURES ABSOLUTE UNIFORMITY OF TITAN WELDING ALLOYS

Quality Control in manufacture of TITAN Welding Alloys begins with the selection of the finest available raw materials.

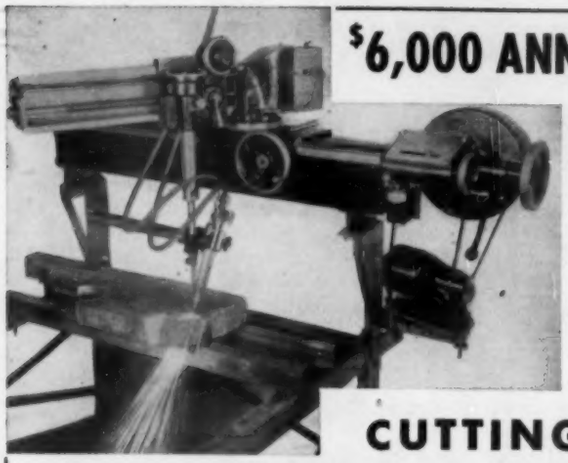
Only the purest raw materials are used: Electrolytic copper 99.96 plus in purity, and electrolytic zinc 99.99 plus. This assures the elimination of elements which if introduced would prove detrimental to quality and uniformity.

Maintenance of unvarying uniformity of mixtures and of casting temperatures, under strict laboratory control, further assures absolute uniformity of TITAN Alloys.

Descriptive literature sent upon request

TITAN METAL MANUFACTURING CO., BELLEFONTE, PA.

TITAN WELDING RODS



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√ Avoids Delays
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Jig Plate—4 hrs. to 8 min.
Face Plate—3½ hrs. to 20 min.
Tool Block—3 hrs. to 10 min.
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Stripper Plate—5 hrs. to 15 min.
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Gear Blank—3½ hrs. to 7 min.
Die Shoe—6 hrs. to 14 min.

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The Ransome Welding Positioner illustrated effectively positions heavy awkward pieces such as that shown. The time saved in this particular installation permits seven men to do the same amount of work ordinarily requiring ten men without the use of the Positioner. "Impossible" positions are conveniently and securely established for efficient speedy welding operations. Write for literature.

The unit shown is one of many installed at the plant of the York Safe and Lock Company, York, Pa.

INDUSTRIAL DIVISION

RANSOME MACHINERY COMPANY
Dunellen, New Jersey

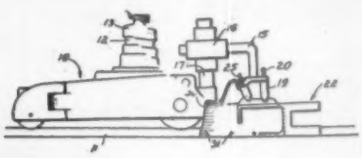
Projection Welding

2,293,247. **David Wendell Fentress,** Hubbard Woods, Ill., assigned to **Chicago Metal Hose Corp.,** Maywood, Ill. Filed Aug. 21, 1939. Issued Aug. 18, 1942. An apparatus for welding a fitting to convoluted metal tubing. A wall of the tubing is held in engagement with a fitting having a projection by means of a flange adapted to project between a pair of adjacent convolutions. The fitting projection is pressed firmly against the wall of the tubing while welding current is passed between fitting and tubing, effecting a projection weld.

» «

Flame-Hardening Control

2,293,281. **John J. Crowe,** Westfield, N. J., assigned to **Air Reduction Co., Inc.** Filed Dec. 10, 1940. Issued Aug. 18, 1942. This patent pertains to a method of producing a uniformly hardened face on a work-piece of variable thickness which is made of material that can be hardened by quick cooling from above a critical temperature. First step in the method is the heating of the face to be hardened above the critical temperature by means of heating flames which are applied progressively so as to supply substantially equal heat input to the regions of different thickness. Then jets of quenching fluid are directed against the heated face, close behind the progressively-applied heating flames. The proximity of the quenching jets and heating flames may be changed so that the jets will strike the face of the work-piece further from the flames at regions where greater thickness of metal causes larger heat loss by conduction.



» «

Hard-Facing Electrode

2,292,694. **Paul E. Jerabek,** Cleveland, assigned to **The Lincoln Electric Co.,** Cleveland. Filed Aug. 7, 1939. Issued Aug. 11, 1942. This patent pertains to a composition for hard-facing metallic articles by means of the electric arc. The mixture contains substantial amounts of iron, carbon, chromium and nickel and also contains a substantial amount of a boride. It does not, however, contain any substantial amount of tungsten.

» «

Hard-Facing Rod

2,292,740. **Arthur T. Cape,** Santa Cruz, Calif., and **Mathias L. Eder,** Canton, O., assigned to **Coast Metals, Inc.,** Canton. Filed Feb. 11, 1942. Issued Aug. 11, 1942. A weld rod for hard-facing purposes, comprising a ferrous alloy consisting of from 1% to 2% carbon, from 23% to 27% chromium, from 10%

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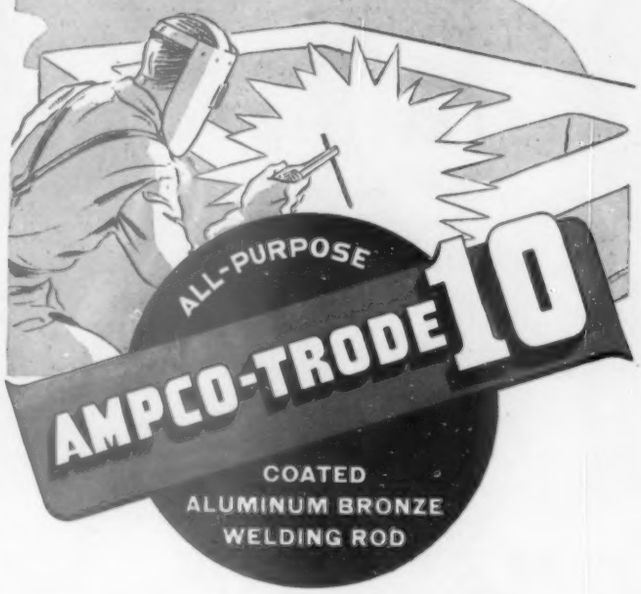

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This welding rod has high strength, and its "hot-ductility", or lack of hot-shortness, is of great importance. It is particularly suitable for joining dissimilar metals by arc welding and it "arc-brazes" mild steel readily.

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J. D. TEBBEN, Chairman Membership Committee
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to 14% nickel and from 6% to 10% molybdenum, the balance of the alloy being substantially all iron. Alloy, it is stated, has a high resistance to wear and abrasion as well as to heavy and repeated impacts; it is likewise resistant to chemical corrosion and to oxidation at high temperatures, and possesses strength at high temperatures. This alloy is capable of forming a sound bond with base metal, and in the molten condition has a viscosity such as to permit easy application to a base metal. The alloy is further characterized by the fact that it is austenitic in the "as-cast" state.

» «

Hard-Facing Rod

2,292,741. **Arthur T. Cape,** Santa Cruz, Calif. and **Mathias L. Eder,** Canton, O., assigned to **Coast Metals, Inc.,** Canton. Filed Feb. 11, 1942. Issued Aug. 11, 1942. A weld rod for hard-facing purposes, comprising a ferrous alloy consisting of from 1% to 2% carbon, from 16% to 20% chromium, from 5% to 7% nickel, from 6% to 10% molybdenum, and from 4% to 5% silicon, the balance of the alloy being substantially all iron. Alloy has high resistance to wear and abrasion, resistance to heavy and repeated impacts, and to chemical corrosion and oxidation at high temperatures, also possessing strength at high temperatures. It is capable of forming a sound bond with a base metal and in the molten condition has a viscosity such as to permit easy application to a base metal. The alloy is further characterized by the fact that it is non-austenitic in the "as-cast" state and has a hardness ranging from 43 to 53 Rockwell C.

» «

Automatic Arc Welding

2,293,079. **Hans Ranke,** Pullach, near Munich, Germany. Filed Oct. 31, 1940. Issued Aug. 18, 1942. An automatic arc welding system in which a fusible electrode is arranged in operative relation to the work to be welded and is advanced toward the work by an electric motor having a rotatable armature

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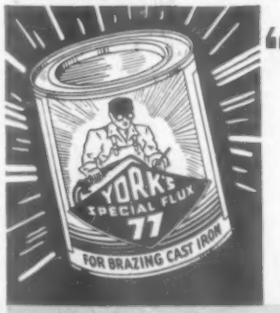

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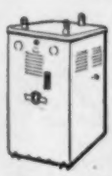

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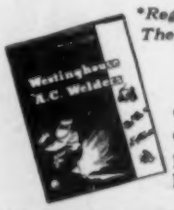

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Dept. 7-N, East Pittsburgh, Pa.

J-70393

operatively associated with the electrode. The feeding rate of electrode is controlled in accordance with changes in an electrical characteristic of the welding zone.

» «

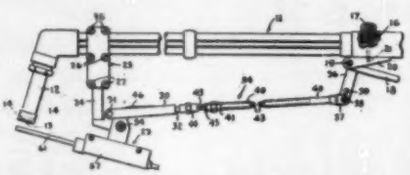
Multiple Spot Welder Control

2,290,925. **Bruno Weicht** and **Max A. Sievers,** Detroit. Filed March 28, 1941. Issued July 28, 1942. This patent pertains to a heat control for a multiple spot welder. Elements are a series of mutually insulated segments, an electrical conductor opposite these segments, a contact device traveling over segments and conductor, a current control device connected to conductor, a tapped resistor between current control and segments, a means for connecting the resistor taps individually and selectively to the segments, a variable cycle metering switch governing the current flow and an individual adjusting member at each segment engageable by the metering switch to determine the number of cycles flowing through each segment.

» «

Flux Cutting Device

2,291,065. **George L. Walker,** Jersey City, N. J., assigned to **Air Reduction Co., Inc.,** New York City. Filed May 4, 1939. Issued July 28, 1942. A

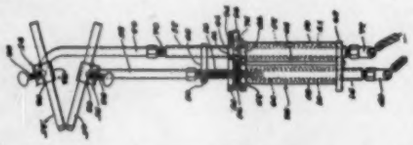


device for advancing a feeder rod to augment the action of a cutting torch. Elements are a reciprocating member that advances the rod during the forward strokes, a handle, a motion-transmitting linkage between the handle and the reciprocating member, a cross-piece outside of the linkage through which one link of the linkage extends, an enlarged end on that link, and a spring surrounding the link and compressed between the cross-piece and the enlarged end to urge the linkage in a direction to move the handle and reciprocating member back to starting position after each feeding stroke.

» «

Electric Arc Torch

2,291,199. **Alf E. Anderson,** Milton, Mass. Filed April 10, 1941. Issued July 28, 1942. An electric torch for arc welding having, in combination, a pair of electrode supporting members and a handle in which they are mounted in spaced and substantially parallel relation. One of these supporting members is mounted to rotate in the handle, moving its electrode into and out of



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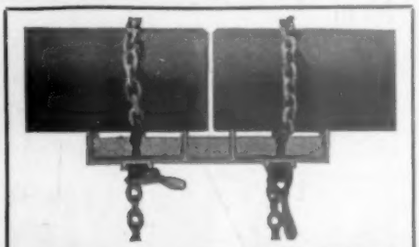

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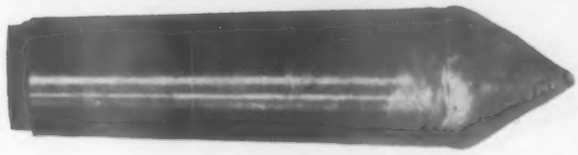

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arcing position; the means for accomplishing this rotation include a flanged collar fixed to one supporting member, a stop member fixed in the handle and arranged to be engaged by the collar to limit the rotation in one direction, and means for positively locking one supporting member in the position into which it may be moved. The latter means includes a hooked lever pivotally mounted on the collar; this lever is arranged to engage stop member to prevent rotation in the other direction.

» «

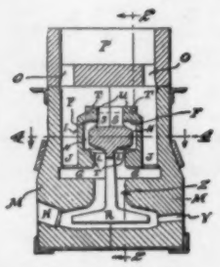
Self-Hardening Rod

2,291,482. **William C. McLott,** Grand Rapids, Mich. Filed Aug. 6, 1941. Issued July 28, 1942. A steel welding rod having a coating of ferro-chrome, ferro-manganese and graphite powder cemented together and around the rod. Weight of steel is approximately 80% of the completed rod and weight of coating approximately 20%.

» «

Thermit Rail Welding

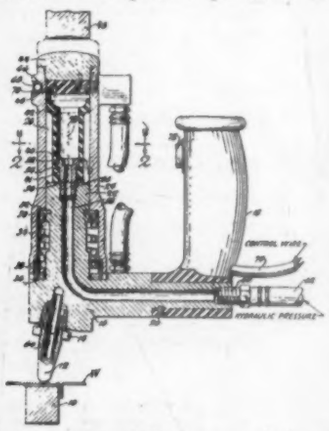
2,292,601. **Edward F. Begtrup,** Jersey City, N. J., assigned to **Metal & Thermit Corp.,** New York City. Filed March 17, 1939. Issued Aug. 11, 1942. This patent pertains to the pressure-fusion welding of rails by the alumino-thermic method. The process comprises abutting the ends of two rails to be welded in such fashion that a gap is left between the bases and webs of rails to receive molten alumino-thermic metal, constructing around the resulting joint a mold provided with a fusion collar-defining space surrounding the webs and bases of rails and including passageways extending substantially horizontally along the under part of the rail heads on either side of the joint and on either side of the rail heads. The passageways terminate in constricted channels spaced slightly from the joint and extending upwardly following the contour of the rail heads. Joint is preheated by passing heated gases upwardly through the collar-defining space, horizontally through the passageways, upwardly through the constricted channels and then horizontally over the tops of the rail heads. After preheating, an alumino-thermic charge is poured into the mold in such manner that the collar-defining space and horizontal passageways are filled with molten alumino-thermic metal. The metal is passed upwardly through the constricted channels, substantially filling them and flowing alumino-thermic slag over the tops of the rail heads. Rail heads are then forced together to pressure weld them.



» «

Spot Welding Gun

2,293,337. **Marcus R. Harris,** Indianapolis, assigned to **General Motors Corp.,** Detroit. Filed Oct. 6, 1939. Issued Aug. 18, 1942. This patent pertains to an electric spot welding gun of the type in which the welding gun serves as a means for applying pressure to the parts to be welded and also a means of "shorting out" the welding current between a bucking bar and electrode on which the work to be welded is



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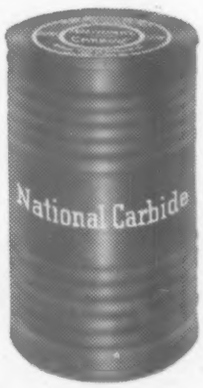

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placed. The combination includes a cylinder formed of current conducting material, a piston having an expansible split skirt, a welding point fixed to one of the latter, a spring for normally maintaining the cylinder and piston in a non-welding position, means to admit fluid to the cylinder to build up pressure therein, and means to expand the split skirt of the piston into current conducting relation with the cylinder after the cylinder and welding point are in pressure engagement with the bucking bar and work, respectively. The last mentioned means includes a flexible-walled member within the split skirt, actuated by fluid pressure built up within the cylinder after cylinder and welding point have engaged the bucking bar and work.

» «

Spot Welding Gun

2,293,338. **Marcus R. Harris,** Indianapolis, assigned to **General Motors Corp.,** Detroit. Filed April 3, 1940. Issued Aug. 18, 1942. This patent pertains to a spot welding gun. Combination comprises a yoke support formed of current conducting material and having a portion forming a contact surface; a yoke likewise formed of current conducting material and having a portion forming a contact surface; a first electrode carried by the yoke; a second electrode and means for moving it to apply pressure to the work to be welded. Yoke is movably carried by the yoke support when the apparatus is in non-welding position and adapted to be in fixed relation with respect to the yoke support during a welding operation. Contact surfaces of the yoke support and yoke are moved relatively to each other after the pressure on the work has reached a certain value, providing a pressure contact between the surfaces so that the yoke and yoke support are in fixed and current conducting relation during a welding operation.

» «

Spot Welder

2,293,330. **Howard C. Cogan** and **Clyde F. Kaunitz,** Bay City, Mich., assigned to **National Electric Welding Machines Co.,** Bay City, Mich. Filed July 12, 1941. Issued Aug. 18, 1942. This resistance welding machine comprises a frame, a carriage reciprocatingly mounted thereon, a work supporting fixture mounted on the carriage, a means for clamping the work on the fixture, a reciprocating ram carrying a plurality of electrodes, and a means synchronized with the ram reciprocation for rotating the work between welding periods.

» «

Spot Welding Mechanism

2,293,393. **Stanley M. Humphrey,** Warren, O., assigned to **Taylor-Winfield Corp.,** Warren. Filed Nov. 25, 1939. Issued Aug. 18, 1942. A spot welding machine comprising a normally fixed electrode, a movable electrode, means to supply welding current to these electrodes, a fluid pressure collapsible member mechanically interconnecting movable electrode and a means for moving the primary electrode. The primary electrode moving means is adapted to reciprocate the collapsible member and the movable electrode. Collapsible member operates to exert a constant expansive force between the movable electrode and primary electrode moving means. During the movement of the primary means towards the electrode and the collapsing of the collapsible member, a means is operative to control the flow of current to the electrodes.

» «

Butt Welding Apparatus

2,293,481. **Leighton A. Wilkie,** Libertyville, Ill. Filed Oct. 28, 1939. Issued Aug. 18, 1942. This patent pertains to a device for welding two ends of a saw band. Device includes a means for holding the ends in alignment, means for simultaneously bringing the ends into abutting engagement and for closing an electric circuit, means for automatically opening the circuit after the welding operation, means for applying continuous pressure for forcing the abutting ends together, means for varying the pressure and means for varying the welding current.

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